# SECTION 100. GENERAL REQUIREMENTS AND COVENANTS











#### SECTION 101. DEFINITION OF TERMS

Wherever in these Specifications or in other contract documents the following terms or pronouns in place of them are used, the intent and meaning shall be interpreted as follows:

**101.01 Abbreviations.** Wherever the following abbreviations are used in these Specifications or on the plans, they are to be construed the same as the respective expressions represented:

AAN	American Association of Nurserymen
AAR	Association of American Railroads
AASHTO	American Association of State Highway

and Transportation Officials

AISC American Institute of Steel Construction ANSI American National Standards Institute

ARA American Railway Association

ARFA American Railway Engineering Association

American Standards Association ASA

ASLA American Society of Landscape Architects ASTM American Society for Testing and Materials

AWG American Wire Gauge

AWPA American Wood Preservers Association AWWA American Water Works Association

AWS American Welding Society **BWC** Bridge Welding Code

United States Environmental Protection Agency EPA

FHWA Federal Highway Administration **FSS** Federal Specifications and Standards General Services Administration **GSA** 

IEMA Illinois Emergency Management Agency IEPA Illinois Environmental Protection Agency ICEA Insulated Cable Engineers Association International Municipal Signal Association IMSA ITE Institute of Transportation Engineers

Illinois Manual on Uniform Traffic Control Devices MUTCD

NEC National Electric Code

NEMA National Electrical Manufacturers Association

NESC National Electrical Safety Code NFPA National Fire Protection Association National Ready-Mix Concrete Association NRMCA

SAE Society of Automotive Engineers

UL **Underwriters Laboratories** USASI United States of America Standards Institute USDA United States Department of Agriculture

101.02 Advertisement. The public announcement, as required by law, inviting bids for work to be performed or materials to be furnished.

101.03 Award. The decision of the Department in the form of a letter of intent to accept the proposal of the lowest responsible bidder for the work, subject to the



approval and execution of a satisfactory contract by the Department, receipt of a bond to secure the performance thereof, and compliance with such other conditions as may be specified or otherwise required by law.

- **101.04 Bidder.** Any individual, firm, partnership, or corporation submitting a proposal for the work contemplated, acting directly or through a duly authorized representative.
- **101.05 Bridge.** A structure, including supports, erected over a depression or an obstruction, such as water, highway, or railroad, and having a track or passageway for carrying traffic or other moving loads, and having a length of more than 6.1 m (20 ft.).

Length. The length of a bridge structure is the overall length measured along the line of survey stationing back to back of backwalls of abutments, if present, otherwise end to end of the bridge floor; but in no case less than the total clear opening of the structure. The length of multiple box culverts shall be between the extreme ends of the openings.

Roadway width. The clear width measured at right angles to the longitudinal centerline of the bridge between the bottom of curbs or guard timbers, or in the case of multiple height of curbs, between the bottoms of the lower risers.

- **101.06** Calendar Day. Every day shown on the calendar.
- **101.07 Chief, Bureau of Construction.** The Engineer in charge of the Central Bureau of Construction in Springfield.
- **101.08 Contract.** The written Agreement between the Department and the Contractor setting forth the obligations of the parties thereunder, including, but not limited to, the performance of the work, the furnishing of labor and materials, and the basis of payment.

The contract includes the invitation for bids, proposal, letter of award, contract form and contract bond, Specifications, Supplemental Specifications, Special Provisions, general and detailed plans, and any Agreements required to complete the construction of the work in an acceptable manner, including authorized extensions thereof, all of which constitute one instrument.

- **101.09 Contract Bond.** The approved form of security furnished by the Contractor and his/her surety as a guaranty that the Contractor will execute the work according to the terms of the contract.
- **101.10 Contract Time.** The number of working days or calendar days or combination allowed for completion of the contract, including authorized time extensions.

When a calendar date of completion is shown in the proposal, the contract shall be completed on or before that date.

**101.11 Contractor.** The individual, firm, partnership, joint venture, or corporation contracting with the Department for performance of prescribed work.

- **101.12 Culvert.** A drainage structure extending across and beneath a traveled way and having a tubular or box type cross section.
- **101.13 Department.** The Department of Transportation of the State of Illinois with principal offices of business at Springfield, when the State is the awarding authority.

The County Board, when a County is the awarding authority.

The Council, the City Council, or the President and Board of Trustees, when a city, village, or town is the awarding authority.

The County or Municipality and the Illinois Department of Transportation when the Illinois Department of Transportation is the awarding agency and the County or Municipality is supervising construction.

- **101.14 District Engineer.** The Engineer in complete charge of the district in which the work under contract is located.
- **101.15 Engineer.** The Director of Highways of the Department of Transportation of the State of Illinois; or authorized representative limited by the particular duties entrusted to that person, when the State is the awarding authority.

The County Superintendent of Highways, when Cook County is the awarding authority, and the County Engineer, when any other county is the awarding authority. The County Superintendent of Highways, when the project is in Cook County, the County Engineer when the project is in any other county and the Illinois Department of Transportation when the Illinois Department of Transportation is the awarding authority and the County is supervising construction.

The City Engineer or Engineer employed by the municipality, when a city, village or town is the awarding agency. The City Engineer or Engineer employed by the municipality, and the Illinois Department of Transportation when the Illinois Department of Transportation is the awarding agency and a city, village or town is supervising construction.

- **101.16 Equipment.** All machinery and equipment, together with the necessary supplies for upkeep and maintenance, and also tools and apparatus necessary for the proper construction and acceptable completion of the work.
- **101.17 Extra Work.** An item of work not provided for in the contract as awarded but found essential to the satisfactory completion of the contract within its intended scope as determined by the Engineer.
- **101.18 Inspector.** The authorized representative of the Engineer assigned to make detailed inspection of any or all portions of the work or material.
- **101.19 Invitation for Bids.** The advertisement for proposals for all work or materials on which bids are required. Such advertisement will indicate with reasonable accuracy the quantity and location of the work to be done or the character and quantity of the material to be furnished and the time and place of the opening of proposals.

- **101.20 Laboratory.** The testing laboratory of the Department or any other testing laboratory which may be designated by the Engineer.
- **101.21 Local Traffic.** Local traffic is traffic whose immediate destination is within the limits of construction or closure, limited to use by persons for necessary access to real property not otherwise accessible by another public way.
- **101.22 Materials.** Any substances specified for use in the construction of the project and its appurtenances.
- **101.23 Median.** The portion of a divided highway separating the traveled ways for traffic in opposite directions.
  - **101.24** Notice to Bidders. The official notice included in the proposal form.
- **101.25** Pavement Structures. The combination of subbase, base course, and surface course placed on a subgrade to support the traffic load and distribute it to the roadbed.
- **101.26 Pay Item.** A specifically described unit of work for which a price is provided in the contract.
- **101.27 Plans.** The approved plans, profiles, typical cross sections, working drawings, and supplemental drawings, or exact reproductions thereof, which show the location, character, dimensions, and details of the work to be done.
- **101.28 Proposal.** The offer of a bidder, on the prescribed form, to perform the work and to furnish the labor and materials at the prices quoted.
- **101.29 Proposal Guaranty.** The security furnished with a bid to guarantee the bidder will enter into the contract if the bid is accepted.
- **101.30 Railroad.** The Railroad or Railway Company whose property is involved in the work.
- **101.31** Railroad Engineer. The Chief Engineer or Superintendent of the Railroad, or authorized representative limited by the particular duties entrusted to him/her.
- **101.32 Ready-Mixed Concrete.** Ready-mixed concrete is a central-mixed, transit-mixed, or shrink-mixed concrete transported and delivered in a plastic state ready for placement in the work.
  - (a) Central-Mixed Concrete. A central-mixed concrete is ready-mixed concrete which has been completely mixed in a stationary mixing plant.
  - (b) Transit-Mixed Concrete. A transit-mixed concrete is ready-mixed concrete completely mixed in a truck mixer.
  - (c) Shrink-Mixed Concrete. A shrink-mixed concrete is ready-mixed concrete which has been partially mixed in a central mixing plant; the mixing then being completed in a truck mixer.

- **101.33 Resident Engineer/Resident Technician.** The authorized representative of the Engineer in immediate charge of the engineering details of a construction project.
- **101.34 Right of Way.** A general term denoting land, property, or interest therein, usually in a strip, acquired for or devoted to transportation purposes.
- **101.35 Roadbed.** The graded portion of a highway within side slopes, prepared as a foundation for the pavement structure and shoulders.
- **101.36** Roadside. A general term denoting the area adjoining the outer edge of the roadway. Extensive areas between the roadways of a divided highway may also be considered roadside.
- **101.37 Roadside Development.** Those items necessary to the complete highway which provide for the preservation of landscape materials and features; the rehabilitation and protection against erosion of all areas disturbed by construction through seeding, sodding, mulching, and the placing of other ground covers; and such suitable planting and other improvements as may increase the effectiveness and enhance the appearance of the highway.
  - **101.38** Roadway. The portion of the right of way within limits of construction.
- **101.39 Shoulder.** The portion of the roadway contiguous with the traveled way for accommodation of stopped vehicles, emergency use, and lateral support of base and surface courses.
- **101.40 Sidewalk.** That portion of the roadway primarily constructed for the use of pedestrians.
- **101.41 Special Provisions.** Additions and revisions to the Standard and Supplemental Specifications covering conditions peculiar to an individual contract.
- **101.42 Specifications.** The body of directions, provisions, and requirements contained herein, or in any supplement adopted by the Department, together with written agreements and all documents of any description made or to be made pertaining to the method or manner of performing and paying for the work, the quantities, and the quality of materials to be furnished under the contract.

#### 101.43 State.

- (a) The State of Illinois, when the State is the awarding authority.
- (b) The County, when a County is the awarding authority.
- (c) The Municipality, when a city, village, or town is the awarding authority.
- **101.44 Structure.** Unless otherwise defined in the Specifications, structures shall comprise all objects constructed of materials other than earth, required by the contract to be built or to be removed, but not including surfacings, base courses, subbases, gutters, curbs, sidewalks, and driveway pavement.
- **101.45 Subcontractor.** An individual, firm, partnership, or corporation who, with the written consent of the Engineer, assumes obligation for performing specified

work

- **101.46 Subgrade.** The top surface of a roadbed upon which the pavement structure and shoulders are constructed.
- **101.47 Substructure.** All of that part of the structure below the bearings of simple and continuous spans, skewbacks of arches, and tops of footings of rigid frames, together with the backwalls, wing walls, and wing protection railings.
  - **101.48 Superstructure.** The entire structure except the substructure.
- **101.49 Supplemental Specifications.** Additions and revisions to the Standard Specifications contained herein that are adopted subsequent to issuance of this book.
- **101.50 Surety.** The corporation, partnership, or individual, other than the Contractor, executing the Contract Bond.
- **101.51 Traffic Control Plan.** Those portions of the contract plans, Special Provisions, Specifications, and Supplemental Specifications having to do with temporary traffic control.
- **101.52 Traveled Way.** The portion of the roadway for the movement of vehicles, exclusive of shoulders and auxiliary lanes.
- **101.53 Utility.** The privately, publicly, or cooperatively owned lines, facilities, and systems for producing, transmitting, or distributing communications, power, electricity, light, heat, gas, oil, crude products, water, steam, waste, storm water not connected with highway drainage, and other similar commodities, including publicly owned fire and police signal systems and street lighting systems, which directly or indirectly serve the public or any part thereof. The term "utility" shall also mean the utility company, inclusive of any wholly owned or controlled subsidiary.
- **101.54 Work.** Work shall mean the furnishing of all labor, materials, equipment, and other incidentals necessary or convenient to the successful completion of the project and the carrying out of all the duties and obligations imposed by the contract.

#### SECTION 102. BIDDING REQUIREMENTS AND CONDITIONS

## 102.01 Prequalification of Bidders.

(a) State of Illinois. When the awarding authority is the State of Illinois, each prospective bidder, prior to being considered for issuance of any proposal forms, will be required to file, on forms furnished by the Department, a prequalification application according to the requirements of the Department's Pregualification Manual.

Upon review of the prequalification application and determination of prequalification ratings, the Department will issue to the Contractor a "Certificate of Eligibility". The certificate indicates the Contractor's financial and work rating limits, and allows the Contractor to request proposal forms. Upon request, the Department will then furnish proposal forms to the

Contractor for bidding according to the requirements of the Prequalification Manual.

The prospective bidder may be requested to file a statement showing the amount and condition of equipment which will be available. Before an award is made, the bidder may be required to furnish an outline of his/her plans for conducting the work.

(b) County or Municipality. When the awarding authority for contract construction work is the County Board of a County, the Council, the City Council, or the President and Board of Trustees of a city, village, or town, each prospective bidder, in evidence of competence, shall furnish the awarding authority as a prerequisite to the release of proposal forms by the awarding authority, a certified or photostatic copy of a "Certificate of Eligibility" issued by the Department of Transportation, according to Article 102.01(a).

The 2 low bidders must file within 24 hours after the letting a sworn affidavit, in triplicate, showing all uncompleted contracts awarded to them and all low bids pending award for Federal, State, County, Municipal and private work, using the blank form made available for this affidavit. One copy shall be filed with the awarding authority and 2 copies with the District office.

**102.02 Contents of Proposal Forms.** Upon request, and subject to the conditions of Article 102.01, the Department will furnish the prequalified, prospective bidders a proposal form. This form will state the location and description of the contemplated construction and will show the estimate of the various quantities and kinds of work to be performed or materials to be furnished, and will have a schedule of items for which unit bid prices are invited. The proposal form will state the time in which the work must be completed, the amount of the proposal guaranty, labor requirements, and the date, time and place of the opening of proposals. The form also will include any Special Provisions or requirements which vary from or are not contained in these Specifications.

**102.03 Issuance of Proposal Forms.** The Department reserves the right to refuse to issue a proposal form for any of the following reasons:

- (a) Lack of competency and adequate machinery, plant, and other equipment, as revealed by the financial statement and experience questionnaires required under Article 102.01.
- (b) Uncompleted work which, in the judgment of the Department, might hinder or prevent the prompt completion of additional work if awarded.
- (c) False information provided on a bidder's "Affidavit of Availability".
- (d) Failure to pay, or satisfactorily settle, all bills due for labor and material on former contracts in force at the time of issuance of proposal forms.
- (e) Failure to comply with any pregualification regulations of the Department.
- (f) Default under previous contracts.
- (g) Unsatisfactory performance record as shown by past work for the Department, judged from the standpoint of workmanship and progress.

- (h) When the Contractor is suspended from eligibility to bid at a public letting where the contract is awarded by, or requires approval of, the Department.
- (i) When any agent, servant, or employee of the prospective bidder currently serves as a member, employee, or agent of a governmental body that is financially involved in the proposed work.
- (j) When any agent, servant, or employee of the prospective bidder has participated in the preparation of plans or specifications for the proposed work.
- **102.04** Interpretation of Quantities in the Bid Schedule. The quantities appearing in the bid schedule are approximate and are prepared for the comparison of bids. Payment to the Contractor will be made only for the actual quantities of work performed and accepted or materials furnished according to the contract. The scheduled quantities of work to be done and materials to be furnished may each be increased, decreased, or omitted as hereinafter provided.
- **102.05** Examination of Plans, Specifications, Special Provisions, and Site of Work. The prospective bidder shall, before submitting a bid, carefully examine the provisions of the contract. The bidder shall inspect in detail the site of the proposed work, investigate and become familiar with all the local conditions affecting the contract and fully acquaint themselves with the detailed requirements of construction. Submission of a bid shall be a conclusive assurance and warranty the bidder has made these examinations and the bidder understands all requirements for the performance of the work. If his/her bid is accepted, the bidder will be responsible for all errors in the proposal resulting from his/her failure or neglect to comply with these instructions. The Department will, in no case, be responsible for any costs, expenses, losses, or change in anticipated profits resulting from such failure or neglect of the bidder to make these examinations.

The bidder shall take no advantage of any error or omission in the proposal and advertised contract. Any prospective bidder who desires an explanation or interpretation of the plans, specification, or any of the contract documents, shall request such in writing from the Central Bureau of Design and Environment, in sufficient time to allow a written reply by the Department that can reach all prospective bidders before submission of their bids. Any reply given a prospective bidder concerning any of the contract documents, plans, and specifications will be furnished to all prospective bidders in the form determined by the Department including, but not limited to, an addendum, if the information is deemed by the Department to be necessary in submitting bids or if the Department concludes the information would aid competition. Oral explanations, interpretations, or instructions given before the submission of bids unless at a prebid conference will not be binding on the Department.

**102.06 Preparation of the Proposal.** Bidders shall submit their proposals on the form furnished by the Department. The proposal shall be executed properly, and bids shall be made for all items indicated in the proposal form, except when alternate bids are asked, a bid on more than one alternate for each item is not required, unless otherwise provided. The bidder shall indicate in figures, a unit price for each of the separate items called for in the proposal form; the bidder shall show the products of the respective quantities and unit prices in the column provided for that purpose, and the gross sum shown in the place indicated in the proposal form shall be the summation of said products. All writing shall be with ink or typewriter, except the



signature of the bidder which shall be written in ink.

If the proposal is made by an individual, that individual's name and business address shall be shown. If made by a firm or partnership, the name and business address of each member of the firm or partnership shall be shown. If made by a corporation, the proposal shall show the names, titles, and business addresses of the president, secretary, and treasurer, and the seal of the corporation shall be affixed and attested by the secretary.

The proposal form will be issued to a prequalified bidder in the same name and style as shown on the "Contractor's Statement of Experience and Financial Condition" used for prequalification and shall be submitted in like manner.

**102.07 Combination Bids.** A combination bid is a total bid received on 2 or more proposals. No combination bids other than those specifically set up by the Department will be considered. Separate proposal forms will be issued for each project in the combination so bids may be submitted on the combination as well as on separate units of the combination. The Department reserves the right to make awards on combination bids or separate bids to the best advantage of the Department.

If a combination bid is submitted on 2 or more proposals, separate proposals on each individual contract shall also be submitted, and unless separate proposals are so submitted, the combination bid will not be considered. If the bidder desires to submit a combination bid, the bidder shall state, in the place provided in the proposal form, the amount of the combination bid for the entire combination.

If a combination bid is submitted on any stipulated combination, and errors are found to exist in computing the gross sum bid on any one or more of the individual proposals, corrections shall be made, by the Department and the amount of the combination bid shall be corrected so that it will be in the same proportion to the sum of the corrected gross sum bid as the combination bid submitted was to the sum of the gross sum bid submitted.

The following provisions shall govern combination bidding:

- (a) A combination bid which is submitted for 2 or more proposals and awarded on that basis shall have the bid prorated against each proposal in proportion to the bid submitted for each proposal.
- (b) Separate contracts shall be executed for each individual proposal included in the combination.
- (c) The completion date for all contracts awarded on a combination bid shall be the latest completion date designated in any one or more of the contracts included in the combination, unless otherwise provided in the contracts.
  - The working days for all contracts awarded on a combination bid shall be the largest number of working days designated in any one or more of the contracts included in the combination, unless otherwise provided in the contracts.
- (d) An extension of time for any one or more contracts awarded on a combination bid shall automatically extend all contracts awarded on the combination.

# Art. 102.07 Bidding Requirements and Conditions

- (e) In the event the Contractor fails to complete any one or all of the contracts on the combination bid by the contract completion date plus any authorized extension, or the contract working days plus any authorized extension, the liquidated damages shall be determined from the schedule of deductions for each day of overrun in contract time in Article 108.09, based on the combination bid total, and shall be computed on the combination and prorated against the 2 or more individual contracts based on the dollar value of each contract.
- (f) The plans and Special Provisions for each separate contract shall be construed separately for all requirements, except as described in paragraphs (a) through (e) listed above.

**102.08 Rejection of Proposals.** The Department reserves the right to reject proposals for any of the conditions in Article 102.03 or for any of the following reasons:

- (a) More than one proposal for the same work from an individual, firm, partnership, or corporation under the same or different names.
- (b) Evidence of collusion among bidders.
- (c) Unbalanced proposals in which the bid prices for some items are, in the judgement of the Department, out of proportion to the bid prices for other items.
- (d) If the proposal does not contain a unit price for each pay item listed except in the case of authorized alternate pay items or lump sum pay items.
- (e) If the proposal form is other than that furnished by the Department; or if the form is altered or any part thereof is detached.
- (f) If there are omissions, erasures, alterations, unauthorized additions, conditional or alternate bids, or irregularities of any kind which may tend to make the proposal incomplete, indefinite, or ambiguous as to its meaning.
- (g) If the bidder adds any provisions reserving the right to accept or reject an award, or to enter into a contract pursuant to an award.
- (h) If the proposal is not accompanied by the proper proposal guaranty.
- (i) If the proposal is prepared with other than ink or typewriter, or otherwise fails to meet the requirements of Article 102.06.

**102.09 Proposal Guaranty.** Each proposal shall be accompanied by a bid bond on the Department form contained in the proposal, executed by a corporate surety company satisfactory to the Department, by a bank cashier's check or a properly certified check for not less than 5 percent of the amount bid, or for the amount specified in the following schedule:

		Amount of Bid	Proposal Guaranty
	Up to	\$ 5,000	\$ 150
\$	5,000	10,000	300
	10,000	50,000	1,000
	50,000	100,000	3,000
	100,000	150,000	5,000
	150,000	250,000	7,500
	250,000	500,000	12,500
	500,000	1,000,000	25,000
1	,000,000	1,500,000	50,000
1	,500,000	2,000,000	75,000
2	2,000,000	3,000,000	100,000
3	3,000,000	5,000,000	150,000
5	5,000,000	7,500,000	250,000
7	,500,000	10,000,000	400,000
10	0,000,000	15,000,000	500,000
15	5,000,000	20,000,000	600,000
20	0,000,000	25,000,000	700,000
25	5,000,000	30,000,000	800,000
30	0,000,000	35,000,000	900,000
	over	35,000,000	1,000,000

In the event that one proposal guaranty check is intended to cover two or more proposals, the amount must be equal to the sum of the proposal guaranties which would be required for each individual proposal.

If a combination bid is submitted, the proposal guaranties which accompany the individual proposals making up the combination will be considered as also covering the combination bid.

Bank cashier's checks or properly certified checks accompanying proposals shall be made payable to the Treasurer, State of Illinois, when the State is the awarding authority; the County Treasurer, when a County is the awarding authority; or the City, Village, or Town Treasurer, when a city, village, or town is the awarding authority.

- **102.10 Delivery of Proposals.** Each proposal should be submitted in a special envelope furnished by the Department. The blank spaces on the envelope shall be filled in correctly to clearly indicate its contents. When an envelope other than the special one furnished by the Department is used, it shall be of the same general size and shape and be similarly marked to clearly indicate its contents. When sent by mail, the sealed proposal shall be addressed to the Department at the address and in care of the official in whose office the bids are to be received. All proposals shall be filed prior to the time and at the place specified in the Notice to Bidders. Proposals received after the time specified will be returned to the bidder unopened.
- **102.11 Withdrawal of Proposals.** Permission will be given a bidder to withdraw a proposal if the bidder makes the request in writing or by telegram before the time for opening proposals.
- **102.12 Public Opening of Proposals.** Proposals will be opened and read publicly at the time and place specified in the Notice to Bidders. Bidders, their authorized agents, and other interested parties are invited to be present.

#### SECTION 103. AWARD AND EXECUTION OF CONTRACT

**103.01 Consideration of Proposals.** After the proposals are opened and read, they will be compared on the basis of the summation of the products of the quantities shown in the bid schedule by the unit bid prices. In the event of a discrepancy between unit bid prices and extensions, the unit bid price shall govern. In awarding contracts, the Department will, in addition to considering the amounts stated in the proposals, take into consideration the responsibility of the various bidders as determined from a study of the data required under Article 102.01, and from other investigations which it may elect to make.

The right is reserved to reject any or all proposals, to waive technicalities, or to advertise for new proposals, if in the judgment of the Department, the best interests of the Department will be promoted thereby.

**103.02 Award of Contract.** The award of contract will be made within 45 calendar days after the opening of proposals to the lowest responsible and qualified bidder whose proposal complies with all the requirements prescribed. The successful bidder will be notified by letter of intent that his/her bid has been accepted, and subject to the following conditions, the bidder will be the Contractor.

An approved contract executed by the Department is required before the State is bound. An award may be cancelled any time by the Department prior to execution in order to protect the public interest and integrity of the bidding process or for any other reason if, in the judgment of the Department, the best interests of the Department will be promoted thereby.

If a contract is not awarded within 45 days after the opening of proposals, bidders may file a written request with the Department for the withdrawal of their bid, and the Department will permit such withdrawal.

**103.03 Return Of Proposal Guaranty.** The proposal guaranty checks of all except the 2 lowest bidders will be returned promptly after the proposals have been checked, tabulated, and the relation of the proposals established. Proposal guaranty checks of the 2 lowest bidders will be returned as soon as the contract and contract bond of the successful bidder have been properly executed and approved. Bid bonds will not be returned.

After a period of 3 working days has elapsed after the date of opening proposals, the Department may permit the 2 lowest bidders to substitute for the bank cashier's checks or certified checks submitted with their proposals as proposal guaranties, bid bonds on the Department forms executed by corporate surety companies satisfactory to the Department.

- **103.04** Requirement of Contract Bond. The Contractor shall furnish the Department a performance and payment bond with good and sufficient sureties in the full amount of the contract as the penal sum. The surety shall be acceptable to the Department, shall waive notice of any changes and extensions of time, and shall submit its bond on the form furnished by the Department.
- **103.05 Execution of Contract.** The contract shall be executed by the successful bidder and returned, together with the Contract Bond, within 15 days after the contract has been mailed to the bidder.



If the bidder to whom award is made is a corporation organized under the laws of a State other than Illinois, the bidder shall furnish the Department a copy of the corporation's Certificate of Authority to do business in the State of Illinois with the return of the executed contract and bond. Failure to furnish such evidence of a Certificate of Authority within the time required will be considered as just cause for the annulment of the award and the forfeiture of the proposal guaranty to the State, not as a penalty, but in payment of liquidated damages sustained as a result of such failure.

**103.06 Failure to Execute Contract.** If the contract is not executed by the Department within 15 days following receipt from the bidder of the properly executed contracts and bonds, the bidder shall have the right to withdraw his/her bid without penalty.

Failure of the successful bidder to execute the contract and file acceptable bonds within 15 days after the contract has been mailed to the bidder shall be just cause for the cancellation of the award and the forfeiture of the proposal guaranty which shall become the property of the Department, not as a penalty, but in liquidation of damages sustained. Award may then be made to the next lowest responsible bidder, or the work may be readvertised and constructed under contract, or otherwise, as the Department may decide.

#### **SECTION 104. SCOPE OF WORK**

**104.01 Intent of the Contract.** The intent of the contract is to prescribe a complete outline of work which the Contractor undertakes to do in full compliance with the plans and specifications. The Contractor shall perform all earthwork, construct all base and surface courses, structures, and such additional, extra, and incidental construction as may be necessary to complete the work to the finished lines, grades and cross sections in an acceptable manner. The Contractor shall furnish all required materials, equipment, tools, labor, and incidentals, unless otherwise provided in the contract, and shall include the cost of these items in the unit prices bid for the several units of work.

**104.02** Alterations, Cancellations, Extensions and Deductions. The Department reserves the right to make, in writing, at any time during work, such changes in quantities and such alterations in work as necessary to satisfactorily complete the project. Such changes in quantities and alterations shall not invalidate the contract nor release the surety, and the Contractor agrees to perform the work as altered.

If the alterations or changes in quantities significantly change the character of the work under the contract, whether or not changed by any such different quantities or alterations, an adjustment, excluding loss of anticipated profits, will be made to the contract. The basis for the adjustment shall be agreed upon prior to the performance of the work. If a basis cannot be agreed upon, then an adjustment will be made either for or against the Contractor in such amount as the Engineer may determine to be fair and equitable.

If alterations or changes in quantities do not significantly change the character of the work to be performed under contract, the altered work will be paid for as provided elsewhere in the contract.

The term "significant change" shall be construed to apply only when the character of the work as altered differs materially in kind or nature from that involved or included in the original proposed construction or when a major item, defined as an item whose total original contract costs exceeds 10 percent of the total original contract amount, is increased in excess of 125 percent or decreased below 75 percent of the original contract quantity.

All alterations, cancellations, extensions, and deductions shall be authorized in writing by the Engineer before work is started. Such authorizations shall set up the items of work involved and the method of payment for each item.

The Contractor shall accept payment for alterations which result in an increase or decrease in the quantities of work to be performed according to the following:

- (a) All increases in work of the type which appear in the contract as pay items accompanied by unit prices shall, except as provided under paragraph (d) herein, be paid for at the contract unit prices. Decreases in quantities included in the contract shall be deducted from the contract at the unit bid prices. No allowance will be made for delays or anticipated profits.
- (b) Major items of work for which the quantities are increased by not more than 125 percent or reduced to not less than 75 percent of the original contract quantities will be paid for as specified in paragraph (a) above. Any adjustments for increased quantities for major items of work increased more than 125 percent shall only apply to that portion in excess of 125 percent of original contract quantities. Any adjustments made for major items of work which are decreased to less than 75 percent of the original contract quantities shall apply to the actual amount of work performed.
- (c) Extra work which is not included in the contract as pay items at unit prices and is not included in other items of the contract will be paid for according to Article 109.04.
- (d) Extra work for which there is a pay item at unit price in the contract which for any one or more of the following reasons materially increases or decreases the cost of the pay item as bid and which is not included in the prices bid for other items in the contract will be paid for according to Article 109.04. This includes:
  - (1) Work involving a substantial change of location.
  - (2) Work which differs in design.
  - (3) Work requiring a change in the type of construction.
- (e) In cases where the Department cancels or alters any portion of the contract items, items which are partially completed shall be paid for as specified in Article 109.06.

Claims for extra work which have not been authorized in writing by the Engineer will be rejected.

**104.03 Differing Site Conditions.** During the progress of the work, if subsurface or latent physical conditions are encountered at the site differing materially from those indicated in the contract or if unknown physical conditions of an unusual nature, differing materially from those ordinarily encountered and generally

recognized as inherent in the work provided for in the contract, are encountered at the site, the party discovering such conditions shall promptly notify the other party in writing of the specific differing conditions before they are disturbed and before the affected work is performed.

Upon written notification, the Engineer will investigate the conditions, and if he/she determines the conditions materially differ and cause an increase or decrease in the cost or time required for the performance of any work under the contract, an adjustment, excluding loss of anticipated profits, will be made and the contract modified in writing accordingly. The Engineer will notify the Contractor of his/her determination whether or not an adjustment of the contract is warranted.

No contract adjustment which results in a benefit to the Contractor will be allowed unless the Contractor has provided the required written notice. No contract adjustment will be allowed for any effects caused on unchanged work.

Any adjustment in compensation because of a change or changes resulting from one or more of the conditions described in the foregoing paragraph will be made according to the Provisions of Article 104.02. Any adjustment in contract time because of such change or changes will be made according to the provisions of Article 108.08.

**104.04 Maintenance of Detours.** The Contractor shall be responsible for maintaining detour routes, except on state designated routes. When the road upon which construction is in progress is closed to public use by the Engineer, the Contractor will, unless otherwise specified, be relieved of all responsibility in connection with the maintenance or marking of suitable detours.

104.05 Rights In and Use of Materials Found on the Work. The Contractor, with the approval of the Engineer, may use on the work such stone, gravel, sand, or other material determined suitable by the Engineer as may be found in the excavation, and will be paid both for the excavation of such materials at the corresponding contract unit price and for the pay item for which the excavated material is used. The Contractor shall replace, at his/her own expense, with other acceptable material, all of that portion of the excavation material so removed and used which was needed for use in the embankments, backfills, approaches, or otherwise. No charge for the materials so used will be made against the Contractor. The Contractor shall not excavate or remove any material from within the highway location which is not within the grading limits, as indicated by the slope and grade lines, without written authorization from the Engineer.

Unless otherwise provided, the material from any existing old structure may be used temporarily by the Contractor in the erection of the new structure. Such material shall not be cut or otherwise damaged except with the approval of the Engineer.

**104.06 Final Clean Up.** Before final acceptance, all borrow pits and ground occupied by the Contractor in connection with the work shall be cleaned of all rubbish, excess materials, temporary structures and equipment, and all parts of the work shall be left in a neat and presentable condition.

The Contractor shall clean off all cement streaks or drippings, paint smears or drippings, rust stains, oil, grease, bituminous materials, dirt, and other foreign materials deposited or accumulated on or in any structure or curb and gutter due to the Contractor's operations.

- **104.07 Value Engineering Proposals.** The Contractor may submit to the Department in writing, proposals for modifying the contract documents to provide innovative, alternative lower cost construction without impairing the essential functions and characteristics of the facility including, but not limited to, service life, reliability, economy of operation, ease of maintenance, necessary standardized features, desired appearance, or design standards.
  - (a) Proposal Submittals. Value Engineering Proposals shall be submitted in two phases as follows:
    - (1) Concept Phase. Prior to the submittal of any Value Engineering Proposal, the Contractor shall submit a brief summary outlining the concept of the proposal to the Central Bureau of Construction and the District Office. Within five working days after receipt of the proposal concept, the Department will notify the Contractor as to whether or not the proposal concept qualifies for consideration as Value Engineering. If it appears, based on the concept, the actual proposal will require a review period exceeding the normal review period, as outlined below, the Contractor will be so advised. Approval of the concept does not constitute or imply approval of the subsequent submittal of the complete Value Engineering Proposal.
    - (2) After the concept has been approved, the Contractor, if electing to proceed with submittal of the complete Value Engineering Proposal, shall submit the proposal simultaneously to the district and the Central Bureau of Construction for review. The district will forward their recommendations to the Central Bureau of Construction within 10 working days after receipt of the proposal, provided the proposal is complete and contains all the required information for review. The Central Bureau of Construction will notify the Contractor as to the acceptability of the proposal within 5 working days of receipt of the district's recommendation, unless additional review time has been established as noted in the concept review process.
  - (b) Contents of Proposal. Value Engineering Proposals shall contain the following information:
    - (1) A Statement that the proposal is submitted as a Value Engineering Proposal.
    - (2) A complete description detailing the proposed modification to the contract documents.
    - (3) A complete cost analysis detailing the unit costs and quantities to be deleted and/or added by the proposal.
    - (4) A complete analysis of the impact the proposed modification will have on the prosecution and progress of the contract.
  - (c) Consideration of Proposal. The following conditions will govern the consideration of Value Engineering Proposals:
    - (1) All proposals apply only to the contract under which it is submitted. The Contractor will be guaranteed propriety of authorship as well as ownership of the proposal until such time it is approved by the

Department. The Department will have the right to use, duplicate, and disclose in whole or in part any data necessary for the utilization of the proposal. The Department retains the right to utilize any accepted proposal or part thereof on any other or subsequent contracts without obligation to the Contractor. This provision is not intended to deny rights provided by law with respect to patented materials or processes.

- (2) If the Department has under consideration certain revisions or modifications to the contract at the time of execution of the contract, the Contractor will be so notified at the preconstruction conference. Revisions or modifications to the contract generated by the Department shall not be incorporated into any Value Engineering Proposal submitted by the Contractor.
- (3) The proposal shall not consist of any experimental products or materials to be incorporated. However, proposals containing the use of alternate methods and equipment, as allowed under Article 108.06, may be presented for consideration.
- (4) The reduction of quantities or deletion of items of work which result from adjustment of the contract to meet field conditions as allowed under Article 104.02, shall not be incorporated into any Value Engineering Proposal. Proposals based solely on the waiving of specifications or contract requirements will not be considered.
- (5) The proposal must be submitted and approved prior to undertaking any work on the proposed modification.
- (6) The Contractor shall have no claim against the Department for any costs or delays resulting from the review process and/or disapproval of any Value Engineering Proposal, including but not limited to, development costs, anticipated profits, increased material cost, and increased labor costs.
- (7) The Department will be the sole judge as to the acceptability of a proposal and the estimated net savings resulting from implementation of the proposal. In determining the estimated net savings, the right is reserved to disregard the contract bid prices if, in the judgement of the Engineer, such prices do not represent a fair measure of the value of work to be performed or to be deleted.
- (8) The Department reserves the right where it deems such action appropriate, to require the Contractor to share in the costs of reviewing and investigating any Value Engineering Proposal. When this requirement is imposed, the Contractor shall indicate his/her acceptance thereof in writing, and such acceptance shall constitute full authority for the Department to deduct amounts payable to the Department from any monies due or that may become due to the Contractor under the contract.
- (9) The Contractor shall be responsible for any modification of the contract plans required as part of the Value Engineering Proposal. When contract plan modifications are included as part of the proposal, the Contractor shall furnish a copy of the modifications to the Department and shall be solely responsible for any errors or omissions resulting

from the modification.

(d) Acceptance of the Proposal. If the Value Engineering Proposal is accepted, the changes will be incorporated into the contract through changes in the quantities of unit bid items, new agreed price items or by force account as appropriate. The cost of the revised work will be paid directly as completed. In addition to such payment, the Department will pay the Contractor a Value Engineering Incentive according to the following criteria.

A = Adjusted cost

B = Original cost

C = Department's cost incurred as a result of investigation and application of the proposal

For contracts less than \$1,000,000 in awarded value, the Contractor will be paid as follows:



When the total cumulative value of all Value Engineering Proposals submitted for an individual contract is equal to or less than 1.5% of the awarded contract value, payment will be 0.5 (B-A-C).

When the total cumulative value of all Value Engineering Proposals submitted for an individual contract is greater than 1.5% of the awarded contract value, payment will be 0.65 (B-A-C).

For contracts that are at least \$1,000,000 but do not exceed \$5,000,000 in awarded value, the Contractor will be paid as follows:

When the total cumulative value of all Value Engineering Proposals submitted for an individual contract is equal to or less than 2.0% of the awarded contract value, payment will be 0.5 (B-A-C).

When the total cumulative value of all Value Engineering Proposals submitted for an individual contract is greater than 2.0% of the awarded contract value, payment will be 0.65 (B-A-C).

For contracts that exceed \$5,000,000 in awarded value, the Contractor will be paid as follows:

When the total cumulative value of all Value Engineering Proposals submitted for an individual contract is equal to or less than 1.0% of the awarded contract value, payment will be 0.5 (B-A-C).

When the total cumulative value of all Value Engineering Proposals submitted for an individual contract is greater than 1.0% of the awarded contract value, payment will be 0.65 (B-A-C).

#### SECTION 105. CONTROL OF WORK

## 105.01 Authority of Engineer.

All work of the contract shall be completed to the satisfaction of the Engineer. The decision of the Engineer shall be final on all questions which may arise regarding,

including but not limited to, the quality and acceptability of materials and work; the manner of performance; acceptable rates of progress on the work; the interpretation of the contract plans and specifications; the fulfillment of the contract; the measurement of quantities and payment under the contract; and the determination of the existence of changed or differing site conditions.

The Engineer will notify the Contractor in writing if the work is to be suspended wholly or in part due to the failure of the Contractor to carry out provisions of the contract or failure to carry out orders of the Engineer. The work may also be suspended at the Contractor's risk for such periods as the Engineer may deem necessary due to unsuitable weather; for conditions considered unsuitable for the prosecution of the work or for any other condition or reason deemed to be in the public interest.

The contract does not require the Engineer to provide the Contractor with direction or advice on how to do the work. If the Engineer approves or recommends any method or manner for doing the work, the approval or recommendation shall not guarantee following the method or manner will result in compliance with the contract, relieve the Contractor of the risks and obligations of the contract, or create liability for the Department.

In case of failure on the part of the Contractor to execute work ordered by the Engineer, the Engineer may, at the expiration of a period of 48 hours after giving notice in writing to the Contractor, proceed to execute such work as may be deemed necessary, and the cost thereof shall be deducted from compensation due or which may become due the Contractor under the contract.

**105.02 Authority of Railroad Engineer.** Whenever the safety of railroad traffic during construction is concerned, the Railroad Engineer will have jurisdiction over safety measures to be taken and his/her decision as to methods, procedure and measures used shall be final, and any and all Contractors performing work near or about the railroad shall be governed by such decision. Instructions to the Contractor by the Railroad Engineer will be given through the Engineer. Unless otherwise specified, all costs incurred in conforming to the requirements specified herein shall be considered as included in the bid items of the contract and no additional compensation will be allowed.

**105.03 Conformity With Contract.** All work performed and all materials furnished shall be in conformity with the contract and the lines, grades, cross sections, dimensions, and material requirements, including tolerances, shown on the plans or indicated in the contract documents. All work or material which does not conform to the requirements of the contract will be considered unacceptable.

Unacceptable work; whether the result of poor workmanship, use of defective materials, damage through carelessness, or other cause; and unacceptable material shall be removed and replaced or otherwise corrected in an acceptable manner by and at the expense of the Contractor.

The Department reserves the right to accept work produced by the Contractor if the Engineer finds the noncompliant materials, the finished product in which the noncompliant materials are used, or the nonconforming work are in close conformity with the contract. In this event, the Engineer shall document the basis of acceptance by contract modification which may provide for an appropriate adjustment in the contract price for such work or materials as the Engineer deems necessary to conform

to the determination. The determination of the Department will be based on the best engineering judgement of the Engineer and shall be final and binding.

Work done contrary to instructions given by the Engineer, work done beyond the lines shown on the plans, or as given by the Engineer, or any extra work done without written approval given by the Engineer will be considered as unacceptable and will not be paid for under the contract. Work so done may be ordered removed or replaced at the Contractor's expense.

The statement elsewhere in the contract of remedies for the use of unacceptable materials or for unacceptable work shall not be exclusive of the remedies provided in this Article unless expressly provided therein.

Upon failure of the Contractor to comply with any order of the Engineer made under the provisions of this Article, the Engineer will have authority to cause the unacceptable work to be corrected, removed or replaced, and to deduct the cost from any monies due or to become due the Contractor.

**105.04** Plans and Working Drawings. Plans showing details as are necessary to give a comprehensive idea of the construction contemplated will be furnished by the Department. The Department reserves the right to further detail and illustrate the work. The Engineer may furnish the Contractor additional plans and explanations consistent with the original plans. The Contractor shall perform the work according to these additional plans and explanations.

The Contractor shall submit to the Engineer for approval such additional shop, working, or layout drawings pertaining to the construction of the work, as may be required, and prior to the approval of such plans or drawings, any work done or materials ordered shall be at the Contractor's risk. The drawings shall be provided sufficiently in advance of actual need in order to allow for review by the Department and other agencies. The Engineer will require a minimum of up to 30 calendar days for review after receipt of the submittal by the Department. The review may involve rejection, revision, or resubmittal, in which case, the time may increase if the drawings do not meet contract requirements or do not contain sufficient detail. The written approval of the Engineer is required before proceeding with the work represented by the drawings. Approval by the Engineer shall not confer upon the Department any responsibility for the accuracy of the drawings. The Contractor shall bear all risk and costs for work delay caused by nonapproval of the drawings.

When the contract includes work adjacent to a railroad and falsework, cofferdams, or sheeting is required, the Contractor shall submit to the Engineer for approval and the Railroad Engineer's approval, plans for the falsework, cofferdams, or sheeting. The plans shall be submitted sufficiently in advance of the time the Contractor intends to start work to permit checking. No such work shall be started prior to receipt by the Contractor of approval of the plans for the falsework, cofferdams, or sheeting. The Contractor shall give the Railroad Engineer not less than 10 days notice, in writing, prior to beginning of such construction. The cost of furnishing such drawings shall be included in the contract and no additional compensation will be allowed the Contractor for any delays resulting therefrom.

**105.05** Coordination of the Contract Documents. The contract is intended to describe a complete work. In case of discrepancy, calculated dimensions govern over scaled dimensions and the following relationships apply:

Special Provisions\* hold over: Plans

Recurring Special Provisions Supplemental Specifications

**Specifications** 

Plans hold over: Recurring Special Provisions

Supplemental Specifications

Specifications

Recurring Special Provisions hold over: Supplemental Specifications

Specifications

Supplemental Specifications hold over: Specifications

Details Plans hold over: Standard Plans

**105.06** Cooperation by Contractor. The Contractor will be supplied with a minimum of 2 sets of approved plans and contract assemblies including Special Provisions, one set of which the Contractor shall keep available on the work at all times.

The Contractor shall give the work constant attention necessary to facilitate the progress thereof, and shall cooperate with the Engineer, appointed inspectors and other contractors in every way possible.

The Contractor shall have on the work at all times, as the Contractor's agent, a competent English-speaking superintendent capable of reading and thoroughly understanding the plans and Specifications and thoroughly experienced in the type of work being performed, who shall receive instructions from the Engineer or authorized representatives. The superintendent shall have full authority to execute orders or directions of the Engineer without delay, and to promptly supply such materials, equipment, tools, labor, and incidentals as may be required. Such superintendent shall be furnished irrespective of the amount of work sublet.

- **105.07 Cooperation with Utilities.** The adjustment of utilities consists of the relocation, removal, replacement, rearrangements, reconstruction, improvement, disconnection, connection, shifting, or altering of an existing utility facility in any manner.
  - (a) Known Utilities. All known existing utilities are indicated on the plans. Utilities which are to be adjusted shall be adjusted by the utility owner or the owner's representative or by the Contractor as a contract item. Generally, arrangements for adjusting existing utilities will be made by the Department prior to project construction; however, utilities will not necessarily be adjusted in advance of project construction and, in some cases, utilities will not be removed from the proposed construction limits. When utility adjustments must be performed in conjunction with construction, the utility adjustment work will be shown on the plans and/or covered by Special Provisions. When the Contractor discovers a utility not adjusted by the owner and not shown on the plans or described in the Special Provisions, the Contractor shall not interfere with said utility, and shall take proper

<sup>\*</sup> Except Standards with revision numbers listed in the Index Sheets of the plans shall hold precedence over standard numbers listed anywhere else.

#### Control of Work

precautions to prevent damage or interruption of the utility and shall promptly notify the Engineer of the nature and location of said utility.

All necessary adjustments, as determined by the Engineer, of utilities not shown on the plans or not identified by markers, will be made at no cost to the Contractor except traffic structures, light poles, etc., that are normally located within the proposed construction limits as hereinafter defined will not be adjusted unless required by the proposed improvement.

- (1) Limits of Proposed Construction for Utilities Paralleling the Roadway. For the purpose of this Article, limits of proposed construction for utilities extending in the same longitudinal direction as the roadway, shall be defined as follows:
  - a. The horizontal limits shall be a vertical plane, outside of, parallel to, and 600 mm (2 ft.) distant at right angles from the plan or revised slope limits.

In cases where the limits of excavation for structures are not shown on the plans, the horizontal limits shall be a vertical plane 1.2 m (4 ft.) outside the edges of structure footings or the structure where no footings are required.

- b. The upper vertical limits shall be the regulations governing the roadbed clearance for the specific utility involved.
- c. The lower vertical limits shall be the limits of excavation.
- (2) Limits of Proposed Construction for Utilities Crossing the Roadway. For the purpose of this Article, limits of proposed construction for utilities crossing the roadway in a generally transverse direction shall be defined as follows:
  - a. Utilities crossing excavations for structures that are normally made by trenching such as sewers, underdrains, etc. and all minor structures such as manholes, inlets, foundations for signs, foundations for traffic signals, etc., the limits shall be the space to be occupied by the proposed permanent construction unless otherwise required by the regulations governing the specific utility involved.
  - For utilities crossing the proposed site of major structures such as bridges, sign trusses, etc., the limits shall be as defined above for utilities extending in the same general direction as the roadway.

The Contractor may make arrangements for adjustment of utilities outside of the limits of proposed construction provided the Contractor furnishes the Department with a signed agreement with the utility owner covering the adjustments to be made. The cost of any adjustments made outside the limits of proposed construction shall be the responsibility of the Contractor unless otherwise provided.

The Department will request all utility owners to field locate their facilities which may interfere with construction operations in both horizontal and

vertical alignment. The Engineer will make the request for location from the utility after receipt of notice from the Contractor. The utility owners are to be given reasonable notice by the Engineer before field location is needed by the Contractor. On request, the Engineer will make an inspection to verify that the utility company has field located its facilities, but will not assume responsibility for the accuracy of such work. The Contractor shall be responsible for maintaining the excavations or markers provided by the utility owners. This field location procedure may be waived if the utility owner has stated in writing to the Department it is satisfied the construction plans are sufficiently accurate. If the utility owner does not submit such statement to the Department, and they do not field locate their facilities in both horizontal and vertical alignment, the Engineer will authorize the Contractor in writing to proceed to locate the facilities in the most economical and reasonable manner, subject to the approval of the Engineer, and be paid according to Article 109.04.

The Contractor shall coordinate his/her operations with any planned utility adjustment or new installation and the Contractor shall take all precautions to prevent disturbance or damage to utility facilities. Any failure on the part of the utility owner, or their representative, to proceed with any planned utility adjustment or new installation shall be reported promptly by the Contractor to the Engineer orally and in writing.

The Contractor shall take all necessary precautions for the protection of the utility facilities. The Contractor shall be responsible for any damage or destruction of utility facilities resulting from neglect, misconduct, or omission in the Contractor's manner or method of execution or nonexecution of the work, or caused by defective work or the use of unsatisfactory materials. Whenever any damage or destruction of a utility facility occurs as a result of work performed by the Contractor, the utility company will be immediately notified. The utility company will make arrangements to restore such facility to a condition equal to that existing before any such damage or destruction was done.

It is understood and agreed that the Contractor has considered in the bid all of the permanent and temporary utilities in their present and/or relocated positions.



No additional compensation will be allowed for any delays, inconvenience, or damage sustained by the Contractor due to any interference from the said utility facilities except as hereinafter provided for as an unknown utility.

- (b) Unknown Utilities. The requirements stated above for known utilities shall apply to unknown utilities except when the contract involves streets or highways under the jurisdiction of the Illinois Department of Transportation, compensation will be allowed for delays caused by unknown utilities that meet the following conditions:
  - (1) Definition. An unknown utility is defined as an active or inactive underground transmission facility (excluding service connections) which is neither (a) shown in any way in any location on the plans, (b) included in the proposal, nor (c) identified in writing by the Department to the Contractor prior to the letting. If the existence of an unknown

#### Control of Work

utility is established and brought to the attention of the Contractor after the letting date, the Contractor must determine whether the discovery of the utility will cause a delay and, when applicable, file with the Engineer as provided herein.

- (2) Compensation. Compensation will not be allowed for delays, inconveniences or damages sustained by the Contractor from utilities not meeting the above definition or if the discovery of an unknown utility does not cause a shutdown of the work applicable to the utility but only a change in the rate of progress. Compensation for delays (not for inconvenience or damage) caused by an unknown utility will be permitted when the Engineer is notified promptly of the delay. Compensation will not be allowed for any part of a delay claim occurring more than 2 hours prior to such notification. When the Contractor is notified of the existence of an unknown utility prior to starting construction of the project, the Contractor will have 30 days in which to notify the Engineer of the proposed delay claim.
- (3) Minor and Major Delays. Minor and Major Delays are defined as follows:
  - Minor Delay. When the Contractor's operation is stopped by the unknown utility for more than 2 hours, but not to exceed 3 weeks.
  - b. Major Delay. When the Contractor's operation is stopped by the unknown utility for more than 3 weeks.
- (4) Payment. Payment for Minor and Major Delays will be made as follows:
  - a. Minor Delay. Labor idled which cannot be used on other work will be paid for according to the provisions of Sub-article 109.04 (b)(1) and (2) for the time between start of the delay and the minimum remaining hours in the work shift required by the prevailing practice in the area.

Equipment idled which cannot be used on other work will be paid for according to the provisions of Sub-article 109.04 (b)(4). The length of time paid for will be the time between start of delay and 8 hours working time from start of shift being worked.

For delays exceeding the initial shift, excluding Saturdays, Sundays and Holidays, Contractor-owned equipment idled by the delay which cannot be used on other work and remaining at the work site, will be paid at one-half the rate permitted in Sub-article 109.04 (b)(4) using a maximum 8 hours per day for computation purposes. Equipment rented from an independent source will be paid at rates being paid by the Contractor plus move-in move-out costs, but the total amount paid will not exceed 3 weeks rental.

Additional traffic control required as a result of the operation(s) delayed will be paid for according to Article 109.04.

b. Major Delay. Labor will be the same as for Minor Delay.

Equipment will be the same as for Minor Delay except Contractor-owned equipment will be limited to 3 weeks plus the cost of move-out to either the Contractor's yard or another job, whichever is less. Rental equipment may be paid for longer than 3 weeks provided the Contractor presents adequate support to the Department (including lease agreement) to show retaining equipment on the job is the most economical course to follow and in the public interest.

Additional traffic control required as a result of the operation(s) delayed will be paid for according to Article 109.04 for the total length of the delay.

If the delay is clearly shown to have caused work, which would have otherwise been completed, to be done after material or labor costs have increased, such increases may be paid. Payment for materials will be limited to increased cost substantiated by documentation furnished by the Contractor. Payment for increased labor rates will include those items in Sub-article 109.04 (b)(1) and (2) except the 35 percent and 10 percent additives will not be permitted. A delay occurring between November 30 and May 1, when work has not started, will not be considered as eligible for payment of measured labor and material costs.

Project overhead (not including interest) will be allowed when all progress on the contract has been delayed, and will be calculated as 15 percent of the delay claim.

- (5) Other Obligations of Contractor. Upon payment of a claim under this provision, the Contractor shall assign subrogation rights to the Department for the Department's efforts of recovery from any other party for monies paid by the Department as a result of any claim under this Provision. The Contractor shall fully cooperate with the Department in its efforts to recover from another party any money paid to the Contractor for delay damages under this Provision.
- **105.08 Cooperation Between Contractors.** The Department reserves the right at any time to contract for and perform other or additional work on or near the work covered by the contract. Each Contractor shall conduct his/her work so as not to interfere with or hinder the progress or completion of the work being performed by other Contractors. In case of dispute, the Engineer shall be the referee and the Engineer's decision shall be final and binding on all.

Each Contractor involved shall assume all liability, financial or otherwise, in connection with his/her contract, and shall protect and save harmless the Department from any and all damages or claims that may arise because of inconvenience, delay, or loss experienced by the Contractor because of the presence and operation of other Contractors working within the limits of the same improvement. Each Contractor shall assume all responsibility for all work not completed or accepted because of the presence and operations of the other Contractors.

The Contractor shall arrange the work and shall place and dispose of the materials being used so as not to interfere with the operations of the other Contractors within the limits of the same project. The Contractor shall join his/her work with that of the others in an acceptable manner and shall perform it in proper sequence to that of the others.

**105.09 Survey Control Points.** Survey control points will be set by the Engineer, unless specified otherwise in the contract, to establish the horizontal and vertical control required for construction of the various contract items of work. The Department will be responsible for the accuracy of the control points and other lines and elevations set by the Engineer. The Contractor shall assume full responsibility for all dimensions and measurements taken or derived by the Contractor from control points set by the Engineer.

The Contractor shall preserve and protect all control points set by the Engineer. If the Contractor removes, disturbs, or otherwise displaces any control point, without the prior approval of the Engineer, the Engineer may deduct the direct engineering cost incurred by the Department in re-establishing the control point from compensation due the Contractor.

The Contractor shall furnish, as directed by the Engineer, the type, size, quality, and quantity of material required to establish control points for the work. The cost incurred by the Contractor in complying with this requirement shall be considered as included in the contract unit prices bid for the various items of work involved and no additional compensation will be allowed.

- **105.10** Authority and Duties of Resident Engineer. The Resident Engineer is responsible for the administration and satisfactory completion of an assigned construction project. The Resident Engineer has the authority to reject defective work or material and to suspend any work being improperly performed.
- **105.11 Duties of the Inspector.** Inspectors employed by the Department will be authorized to inspect all work done and materials furnished. Such inspection may extend to all or any part of the work and to the preparation, fabrication or manufacture of the materials to be used. The inspector will not be authorized to alter or waive the provisions of the contract. The inspector will not be authorized to issue instructions contrary to the plans and Specifications, or to act as foreman for the Contractor.
- **105.12 Inspection of Work.** All materials and each part or detail of the work shall be subject at all times to inspection by the Engineer. Such inspection may include mill, plant, or shop inspection, and any material furnished under the Specifications is subject to such inspection. The Engineer shall be allowed access to all parts of the work and shall be furnished with such information and assistance by the Contractor as is required to make a complete and detailed inspection.

If the Engineer requests, the Contractor shall remove or uncover such portions of the finished work as may be directed. After examination, the Contractor shall restore said portions of the work to the standard required by the Specifications. Should the work thus exposed or examined prove acceptable, the uncovering or removing, and the replacing of the covering or making good of the parts removed will be paid for as extra work; but should the work so exposed or examined prove unacceptable, the uncovering or removing, and the replacing of the covering or making good of the parts removed, will be at the Contractor's expense.

When the contract includes railroad grade separation or grade crossing work, all materials for and each part or detail of the work shall be subject at all times to the inspection of the representatives of the Railroad insofar as Railroad interests are concerned, but such inspection shall in no sense make the Railroad a party to the contract.

**105.13 Final Inspection.** Upon due notice from the Contractor of completion of the entire project, the Engineer will make an inspection. If all construction provided for and contemplated by the contract is found satisfactorily completed according to all of the requirements of the contract, the inspection shall constitute the final inspection and the Engineer will notify the Contractor in writing of the date of final inspection.

If the inspection discloses any work, in whole or in part as being unsatisfactory, the Engineer will give the Contractor the necessary instructions for correction of same, and the Contractor shall immediately comply with such instructions. Upon correction of the work, another inspection will be made which shall constitute the final inspection provided the work has been satisfactorily completed. In such event, the Engineer will notify the Contractor in writing of the date of final inspection.

#### SECTION 106. CONTROL OF MATERIALS

**106.01 Source of Supply and Quality Requirements.** The materials used on the work shall meet all quality requirements of the contract. In order to expedite the inspection and testing of materials, the Contractor shall notify the Engineer of the proposed sources of materials prior to delivery. At the option of the Engineer, materials may be approved at the source of supply before delivery is started. If it is found after trial that sources of supply for previously approved materials do not produce uniform and satisfactory products, or if the product from any source proves unacceptable at any time, the Contractor shall furnish acceptable materials from other sources.

All materials to be permanently incorporated in the work shall be new unless otherwise specifically prescribed in the contract documents.

All iron and steel products, which are to be incorporated into the work shall be domestically manufactured or produced and fabricated. The Contractor shall obtain from the iron or steel producer and/or fabricator, in addition to the mill analysis, a certification that all iron or steel materials meet these domestic source requirements.

The application of all coatings, epoxy, galvanizing, painting, etc., to metal products shall be domestically applied.

Metal materials other than iron and steel may be accepted provided:

- (a) The Contractor notifies the Department in advance of his/her intention to use other than domestically manufactured or produced material.
- (b) Written evidence is provided in English of compliance with all requirements of the Specifications.
- (c) Physical tests conducted by the Bureau of Materials and Physical Research verify the acceptability of the material.

The Contractor is responsible for complying with these conditions so the material can be sampled and tested prior to the time it is required, and no material shall be incorporated in the work until approval is obtained from the Engineer.

**106.02 Unacceptable Materials.** All materials not conforming to the requirements of the contract at the time they are used shall be considered as unacceptable and all such materials will be rejected and shall be removed immediately from the site of the work unless otherwise instructed by the Engineer. If in place, they shall be removed by the Contractor at the his/her expense and replaced with acceptable materials. No rejected material, the defects of which have been corrected, shall be used until approval has been given. Upon failure of the Contractor to comply forthwith with any order of the Engineer pursuant to the provisions of this Article, the Engineer shall have authority to remove and replace defective materials and to deduct the cost of removal and replacement from any monies due or to become due the Contractor.

**106.03** Samples, Tests, Cited Specifications. All materials should be inspected, tested, and approved by the Engineer before incorporation in the work. The Contractor shall give sufficient advance notice of placing orders to permit tests to be completed before the materials are incorporated in the work, and the Contractor shall afford such facilities as the Engineer may require for collecting and forwarding samples and making inspections. All samples shall be furnished without charge to the Department.

Any work in which untested and unaccepted materials are used without approval or written permission of the Engineer shall be performed at the Contractor's risk and may be considered as unacceptable and unauthorized and will not be paid for. Unless otherwise designated, tests according to the most recent cited standard methods of AASHTO or ASTM, which are current on the date of advertisement for bids, or with other standard methods of sampling or testing adopted by the Engineer, will be made by and at the expense of the Department. Samples will be taken by a qualified representative of the Department. All materials being used are subject to inspection, test or rejection at any time. When requested by the Department, the Contractor shall furnish a complete written statement of the origin, composition, and manufacture of any or all materials (manufactured, produced, or grown) to be used in the work.

Citations. Wherever in the Specifications an abbreviated citation, from those listed in Article 101.01, is used followed by an appropriate serial designation, it shall be construed to mean the latest test or specification as the case may be, either as standards, tentative standards, interims, revisions, or amendments, in effect on the date of invitation for bids.

**106.04 Plant Inspection.** The Engineer may undertake the inspection of materials at the source. In the event plant inspection is undertaken, the Engineer shall have the cooperation and assistance of the Contractor and the producer with whom the Contractor has contracted for materials, and shall have full entry at all times to such parts of the plant as may concern the manufacturer or production of the materials being furnished.

If required by the Engineer, the material producer, manufacturer, or distributor shall furnish an approved building for the use of the inspector. Such building shall be located conveniently near the plant independent of any building used by the material producer, and equipped essentially to the requirements of Article 670.04.

When required by the Engineer, all necessary testing equipment and labor needed to test samples also shall be furnished.

Adequate safety measures shall be provided and maintained.

It is understood that the Department reserves the right to retest all materials which have been tested and accepted at the source of supply after the same have been delivered and to reject all materials which, when retested, do not meet the requirements of these Specifications, or those established for the specific project.

**106.05 Source of Materials.** The source of supply of each material used shall be approved by the Engineer before delivery is started. If sources previously approved are found to be unacceptable at any time and fail to produce materials satisfactory to the Department, the Contractor shall furnish materials from other approved sources.

If the Contractor decides to investigate new sources of supply, the Contractor shall furnish without charge such preliminary samples as the Department may require. Tests will be made on these preliminary samples and reports rendered, but it is understood that such tests are for informatory purposes only and tests shall not be construed as a guarantee of acceptance of any material which may be delivered later for incorporation in the work. Only materials actually delivered for use will be considered, and their acceptance will be based solely upon the results of the tests made on these materials.

If the Contractor installs equipment or apparatus to produce materials from new sources of supply, the Contractor does so at his/her own risk, and the Contractor shall assume full responsibility for the production of uniform and satisfactory materials. In case of failure of a source of supply to produce materials satisfactory to the Department, the Contractor shall indemnify and save harmless the Department from any and all claims for loss or damage of whatever nature which the Contractor may have suffered by reason of the installation of equipment and the operation of such sources of supply.

When materials are furnished to the Contractor by the Department for inclusion in the work, the Contractor's responsibility for all such materials shall be the same as for materials furnished by the Contractor.

- **106.06 Stored Materials.** If it is necessary to store materials, they shall be protected in such a manner as to ensure the preservation of their quality and fitness for the work. All stored materials shall be inspected at the time of use in the work, even though they may have been inspected and approved before being placed in storage. The Contractor may use the right of way for storage of materials, but the stockpiles shall be confined to such cleared areas as may be approved by the Engineer. If stockpiling is done outside of the right of way, the additional space required shall be provided by the Contractor at the Contractor's expense.
- **106.07 Handling Materials.** All materials shall be handled in such manner as to preserve their quality and fitness for the work. Aggregates shall be transported from the storage sites to the work in tight vehicles so constructed as to prevent loss or segregation of materials after loading and measuring in order to prevent inconsistencies in the quantities of materials intended for incorporation in the work as loaded, and the quantities as actually received at the place of operations.

- **106.08 Certification of Structural Steel Fabricator.** All structural steel fabricators performing work on the main load carrying components of steel structures shall be certified under the appropriate category of the AISC Quality Certification Program as follows:
  - (a) Fabricators of welded plate girders, box girders, trusses, and arches shall be certified under Category MBr (Major Steel Bridges).
  - (b) Fabricators of rolled beam structures, either simple span or continuous, and overhead sign structures shall be certified under Category SBr (Simple Steel Bridges).

# SECTION 107. LEGAL REGULATIONS AND RESPONSIBILITY TO PUBLIC

- **107.01 Laws to be Observed.** The Contractor shall at all times observe and comply with all Federal and State laws, local laws, ordinances, and regulations which in any manner affect the conduct of the work, and all such orders or enactments as exist at the present and which may be enacted later, of legislative bodies or tribunals having legal jurisdiction or which may have affect over the work, and no plea of misunderstanding or ignorance thereof will be considered. The Contractor shall indemnify and save harmless the State and all of its officers, agents, employees, and servants against any claim or liability arising from or based on the violation of such law, ordinance, regulation, order or enactment, whether by the Contractor or anyone subject to the control of the Contractor.
- **107.02 Worker's Compensation Insurance.** Prior to the approval of his/her contract by the Department, the Contractor shall furnish to the Department certificates of insurance covering Worker's Compensation, or satisfactory evidence that this liability is otherwise taken care of according to Section 4 (a) of the "Worker's Compensation Act of the State of Illinois" as amended.

Such insurance, or other means of protection as herein provided, shall be kept in force until all work to be performed under the terms of the contract has been completed and accepted according to the Specifications, and it is hereby understood and agreed the maintenance of such insurance or other protection, until acceptance of the work by the Department, is a part of the contract. Failure to maintain such insurance, cancellation by the Industrial Commission of its approval of such other means of protection as might have been elected, or any other act which results in lack of protection under the said "Worker's Compensation Act" may be considered as a breach of the contract.

- **107.03 Employment Preference.** The Contractor shall comply with the "Veterans Preference Act" as amended. The foregoing requirements shall not be applied to discriminate or give preference to veterans of a district over veterans of any political jurisdiction, state, possession, or territory of the United States on Federal-aid projects.
- **107.04 Permits and Licenses.** The Contractor shall procure all permits and licenses, pay all charges and fees, and give all notices necessary and incident to the due and lawful prosecution of the work.

The Contractor before entering upon the right of way of a railroad for the

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performance of any construction work, or work preparatory thereto, shall secure permission from the Railroad Engineer for the occupancy and use of the railroad's right of way outside the limits of the railroad grade separation structure or grade crossing; and, in addition, the Contractor shall confer with the Railroad Engineer relative to railroad requirements for clearances, operation, and general safety regulation.

- 107.05 Patented Devices, Material, and Processes. If any design, device, material, or process covered by letters, patent, or copyright is used by the Contractor, whether required or not, the Contractor shall provide for such use by suitable legal agreement with the patentee or owner, guaranteeing the Department indemnity from and against all claims for infringement, and shall include the cost of such agreement in the price bid for the work. It shall be the duty of the Contractor, if so demanded by the Department, to furnish said Department with a copy of the legal agreement with the patentee or owner, and if such copy is not furnished when demanded, then the Department may, if it so elects, withhold any and all payments to said Contractor until said legal agreement is furnished. If a suitable legal agreement with the patentee or owner is not made as required herein, the Contractor and surety shall indemnify and save harmless the Department from any and all claims for infringement by reason of the use of any such patented design, device, material, or process, or any trademark or copyright in connection with the work agreed to be performed under the contract. and shall indemnify the Department for any cost, expense, and damages which it may be obliged to pay by reason of any such infringement at any time during the prosecution or after the completion of the work.
- **107.06** Restoration of Surfaces Opened by Permit. Any individual, firm, partnership or corporation wishing to make an opening in the surface must secure a permit from the Department, and the Contractor shall not allow any person to make an opening unless a duly authorized permit from the Department is presented. Upon the presentation of a duly authorized permit, the Contractor shall allow parties bearing such permits to make openings in the surface. The Contractor shall, if ordered by the Engineer in writing, make, in a manner approved by the Engineer, all necessary repairs to such openings, and such necessary work ordered by the Engineer shall be paid for as extra work as provided in Article 109.04.
- **107.07 Federal Aid Provision.** When the United States Government pays all or any portion of the cost of a project, the Federal laws and the rules and regulations made pursuant to such laws must be observed by the Contractor, and the work shall be subject to the inspection of the appropriate Federal agency.

Such inspection shall in no sense make the Federal Government a party to this contract and will in no way interfere with the rights of either party hereunder.

- **107.08 Sanitary Provisions.** The Contractor shall provide and maintain in a neat, sanitary condition such accommodations for the use of the Contractor's employees and Department representatives as may be necessary to comply with the requirements of the State and Local Boards of Health, or of other authorities having jurisdiction.
- **107.09 Public Convenience and Safety.** The Contractor shall notify the Engineer at least 3 days in advance of the starting of any construction work which might in any way inconvenience or endanger traffic, so arrangements may be made,

if necessary, for closing the road and providing suitable detours. The Contractor shall at all times conduct the work in such a manner as to ensure the least obstruction to vehicular and pedestrian traffic. The convenience of the general public and residents along the highway shall be provided for in an adequate and satisfactory manner. When directed by the Engineer, the Contractor shall provide and maintain an acceptable surface aggregate for temporary roads and approaches for access to driveways, houses, buildings or other property abutting the highway or street being improved. The cost incurred by the Contractor for providing temporary roads will be paid for as extra work as provided in Article 109.04.

The Engineer may require the Contractor to finish a section on which work is in progress before work is started on any additional sections if the opening of such section is essential to public convenience.



No broken pavement, open holes, trenches, barricades, cones, or drums will remain on or adjacent to the traveled way and all lanes shall be open to traffic during any legal holiday period, except where stage construction with traffic control is provided. In addition, for multilane facilities when Independence Day falls on a Tuesday, Wednesday or Thursday, at least one lane in each direction shall be open to traffic. The legal holidays include:

New Year's Day
Memorial Day
Independence Day

Labor Day
Thanksgiving Day
Christmas Day

The length of the holiday period shall vary as follows, depending on the day of the week the legal holiday falls on or is observed:

Day of Holiday	Length of Holiday Period
Sunday Monday	3 p.m. Friday-12 midnight Sunday 3 p.m. Friday-12 midnight Monday
Tuesday	3 p.m. Friday-12 midnight Tuesday
Wednesday	3 p.m. Tuesday-12 midnight Wednesday
Thursday	3 p.m. Wednesday-12 midnight Sunday
Friday	3 p.m. Thursday-12 midnight Sunday
Saturday	3 p.m. Friday-12 midnight Sunday

When any construction work is performed on structures over pavements which are open to traffic, the Contractor shall protect the traffic from falling objects and/or materials. The Contractor's method of protection shall be subject to the approval of the Engineer and the cost thereof shall be included in the work involved.

The following vertical and horizontal restrictions shall pertain to roads as defined in the Illinois Highway Code, Article 2, Division 1, Section 2-101 when construction is being performed with the road open to traffic:

In the event that any construction work will create a horizontal or vertical clearance restriction or will cause a reduction in the existing vertical or horizontal clearance on the highway under construction, the Contractor shall notify the Engineer (in writing) one week in advance of performing the work involved.

Notification of horizontal clearance changes shall include those in which the

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existing lane width is reduced. Notification of vertical clearance changes shall include all vertical changes regardless of the height involved. Notifications shall include both permanent and temporary changes.

In the event that the vertical clearance to any road surface will become less than 4.42 m (14 1/2 ft.), the Contractor (in addition to the aforementioned notifications) shall furnish and install LOW CLEARANCE signs and any required advance warning signs according to the current edition of the State of Illinois Manual on Uniform Traffic Control Devices for Streets and Highways, said signs to be placed at locations designated by the Engineer. The designated signs shall be required for permanent clearance changes and for temporary features such as safety nets and false work when the road is open to traffic. When temporary features are to be removed or revised, the Contractor shall again notify the Engineer as provided herein and shall revise the signs to indicate the revised clearance condition.

Except for the cost of providing temporary roads and approaches, all labor, materials, and equipment required to satisfy the conditions stated herein shall be considered as included in the contract bid prices and no extra compensation will be allowed. These requirements shall not reduce the obligations of the Contractor concerning traffic control and responsibility to the public as provided for in the plans and elsewhere in the Specifications or Special Provisions.

107.10 Temporary Railroad Grade Crossing. The Contractor shall make arrangements with the Railroad for the construction, protection, maintenance, and later removal of any temporary grade crossings, across the tracks of the Railroad necessary for the use of the Contractor during the construction of the improvement. The Contractor shall not at any time cross the Railroad's right of way or tracks with vehicles or equipment of any type or character except at such temporary grade crossing as may be constructed according to a separate private crossing agreement, for which the Railroad shall be reimbursed in the full amount of all costs incurred, and as specified herein, or at an existing open public grade crossing. The Contractor shall reimburse the Railroad promptly for the cost of such work, including travel and other expenses involved in furnishing personnel, based on bills rendered monthly or less frequently. The cost of such temporary grade crossing construction, protection, maintenance, and later removal shall be considered as included in the contract unit prices bid for the various items of work involved, and no additional compensation will be allowed.

**107.11** Insurance Requirements for Railroad-Highway Crossings. For all railroad-highway grade separation work and selected at-grade crossings as indicated in the contract proposal, the Contractor shall obtain Railroad's Protective Liability and Property Damage Liability Insurance according to the requirements specified hereinafter.

Upon receipt of Certificates of Insurance from the Contractor evidencing the required insurance coverages, the Department will request approval of the insurance and permission to enter upon the Railroad's right of way from the Railroad and will advise the Contractor of the approvals. The Contractor shall not enter upon the right of way of a Railroad for the performance of any construction work, or work preparatory thereto until approval of the insurance has been received from the Department. Failure on the part of the Contractor to secure approval of the insurance shall be just cause for the cancellation of the award and forfeiture of the proposal guaranty to the

State, not as a penalty but in payment of liquidated damages sustained as a result of such failure.



The Contractor, with respect to the operations he/she or any Subcontractors perform, will be required to carry in the name of and on behalf of each Railroad involved, Railroad Protective Public Liability and Property Damage Liability Insurance (AAR-AASHTO Form) in limits not less than \$2,000,000 combined single limit per occurrence for bodily injury liability and property damage liability with an aggregate limit of \$6,000,000 over the life of the policy. This insurance shall be according to the form as provided for and to be furnished by the Department. Copies of this form will be furnished on request and no substitutes will be accepted. The Contractor shall furnish the Department the original and one certified copy of the policy.

**107.12 Protection of Railroad Traffic and Property.** All work to be done by the Contractor on the Railroad's right of way shall be performed in a manner satisfactory to the Railroad Engineer. The work shall be performed at such times and in such a manner as not to unnecessarily interfere with the movements of trains or traffic upon the tracks of the Railroad. The Contractor shall use all reasonable care and precaution in order to avoid accidents, damage, delay, or interference with the Railroad's trains or other facilities.

The Contractor shall make provisions satisfactory to the Railroad Engineer against disturbing, in any manner, the Railroad embankment, structures, and tracks during construction. If the work to be performed by the Contractor shall, as determined by the Railroad Engineer, weaken or undermine the Railroad embankment, structures, or tracks, then the said work shall be stopped, upon notice so to do, and the forces of the Railroad will proceed with the performance of the work of strengthening the Railroad embankment, structures, or tracks, and the actual cost thereof shall be borne by the Contractor. Should any damage occur to Railroad property as a result of the Contractor's unauthorized or negligent operations, the Railroad may repair such damages and/or perform any work for protection of its property it may deem necessary and the actual cost thereof shall be borne by the Contractor.

The services of Railroad flaggers will be required when the Contractor's operations will encroach on or over the Railroad's right of way: (a) during the excavation, placing, and removal of cofferdams or sheeting, driving of foundation piling and placing of concrete footings for piers adjacent to the track; (b) driving of pile bents adjacent to the track; (c) construction of the permanent structure including erection and removal of falsework, bracing, or forms over or adjacent to the track; (d) transporting material or equipment across the track; (e) any operations involving direct interference with and/or coming in the close vicinity of power lines or Railroad signal and communication lines, underground cables, fuel oil facilities, or pipe lines which might result in fire or damage to such facilities to endanger Railroad operations, or to endanger the public in the transacting of business on Railroad right of way; (f) fouling of operating clearances or reasonable probability of accidental hazard to Railroad traffic; (g) during removal of portions of existing structures immediately over or adjacent to a track; and (h) at all other times when the Railroad Engineer has determined conditions require such protection and the Engineer has determined conditions warrant such protection and has approved the request.

The Contractor shall notify the Railroad Engineer at least 48 hours in advance of the time when protective services will be required and are to be terminated.

Upon written order of the Engineer, the Contractor shall pay the costs of providing flaggers as specified in this Article with the exception of flaggers required for transporting material or equipment across the track. The Contractor will be reimbursed for the actual amounts paid to which will be added 5 percent of that amount. The cost of providing flaggers for the purpose of transporting material and equipment across the track shall be considered as included in the contract unit prices bid for the various items of work involved, and no additional compensation will be allowed.

When the contract includes Railroad grade separation work, the Contractor shall conduct work so as to cause no temporary or permanent obstruction in any manner in an area affording a minimum vertical clearance of 6.55 m (21 1/2 ft.) above the top of high rail and a minimum horizontal clearance of 2.60 m (8 1/2 ft.) on each side of the centerline of any track, measured at right angles thereto. No materials, supplies, or equipment shall be stored within 4.6 m (15 ft.) of the centerline of any track, measured at right angles thereto. If lesser clearances than the above are required for any part of the work, the Contractor shall secure written authorization from the Railroad Engineer for such lesser clearances not less than 5 days in advance of the start of that part of the work, provided permission has been obtained from the Illinois Commerce Commission. The cost of conforming to these requirements shall be considered as included in the contract unit prices bid for the various items of work involved, and no additional compensation will be allowed.

- **107.13 Bridges Over Navigable Waters.** All work on navigable waters shall be so conducted that free navigation of the waterways will not be interfered with and that the existing navigable depths will not be impaired except as allowed by permit issued by the authority having jurisdiction over the navigable waters.
- **107.14 Maintenance of Traffic.** When work zone traffic control is required along the route under construction, or when any section of road is closed for construction operations of any type, or when any section of the road is opened to traffic prior to completion of all work, the Contractor shall protect the workers and provide for safe and convenient public travel by providing adequate traffic control. The traffic control shall conform to the Traffic Control Plan, included in the contract, and to the requirements of Section 701.
- **107.15 Dirt on Pavement or Structures.** Where the Contractor's equipment is operated on any portion of the pavement or structures used by traffic on or adjacent to the section under construction, the Contractor shall clean the pavement of all dirt and debris at the end of each day's operations, and at other times as directed by the Engineer.

The Contractor shall furnish, erect and maintain SLIPPERY WHEN WET signs at such locations, when required during wet weather.

The cost of this work shall be included in the unit prices bid and no additional compensation will be allowed.

**107.16 Equipment on Pavement and Structures.** The pavement and structures on or adjacent to the work shall be protected, in a manner satisfactory to the Engineer, from damage by lugs or cleats on treads or wheels of equipment.

All equipment used in the prosecution of the work shall comply with the legal

loading limits established by the statutes of the State of Illinois when moved over or operated on any pavement or structure unless permission in writing has been issued by the Engineer. Before using any equipment which may exceed the legal loading, the Contractor shall secure a permit, allowing ample time for making an analysis of stresses to determine whether or not the proposed loading would be within safe limits. The Department will not be responsible for any delay in construction operations or for any costs incurred by the Contractor as a result of compliance with the above requirements.

**107.17 Use of Explosives.** When the use of explosives is necessary for the prosecution of the work, the Contractor shall exercise the utmost care not to endanger life or property, including new work. The Contractor shall be responsible for all damage resulting from the use of explosives.

All explosives shall be stored in a secure manner in compliance with all laws and ordinances, and all such storage places shall be clearly marked. Where no local laws or ordinances apply, storage shall be provided satisfactory to the Engineer and, in general, not closer than 300 m (1000 ft.) from the road or from any building or camping area or place of human occupancy.

The Contractor shall notify each public utility company having structures in proximity to the site of work of the intention to use explosives. Such notice shall be given sufficiently in advance to enable the companies to take such steps as they deem necessary to protect their property from injury.

**107.18** Use of Fire Hydrants. If the Contractor desires to use water from hydrants, the Contractor shall make application to the proper authorities, and shall conform to the municipal ordinances, rules, or regulations concerning their use.

Fire hydrants shall be accessible at all times to the Fire Department. No material or other obstructions shall be placed closer to a fire hydrant than permitted by municipal ordinances, rules, or regulations, or within 1.5 m (5 ft.) of a fire hydrant, in the absence of such ordinances, rules, or regulations.



**107.19 Unexpected Regulated Substances.** If the Contractor encounters or exposes during construction any abnormal condition which may indicate the presence of a regulated substance, work in this area shall be immediately discontinued and the Engineer shall be notified. A regulated substance is a hazardous substance, special waste, or petroleum or any fraction thereof, as those terms are defined in the Illinois Compiled Statutes.

Abnormal conditions shall include, but shall not be limited to presence of underground storage tanks or barrels, discolored earth, metal, wood, etc., visible fumes, obnoxious or unusual odors, excessively hot earth, smoke, or any other condition which appears abnormal that could be a possible indicator of a regulated substance. The conditions shall be treated with extraordinary caution. Appropriate action shall be taken to ensure public and employee safety.

The Contractor's operation shall not resume until so directed by the Engineer. The Department may contact the IEMA. Removal and disposal operations shall be coordinated with the IEPA.

Should the disposition of waste material require special procedures by certified

personnel, the Department will make arrangements with qualified persons to dispose of the material. If the Department provides for removal and disposal operations by forces other than the Contractor's, the Contractor shall pay all costs in connection therewith. The Contractor will then be reimbursed according to Article 109.05.

Disposition of the regulated substances shall be made according to the requirements and regulations of the IEPA. The Contractor shall abide with the Response Action Contractor Indemnification Act of the Illinois Compiled Statutes.

When the Contractor encounters unexpected regulated substances due to the presence of unknown utilities, Article 105.07(b) shall apply; otherwise, if the Engineer does not direct a resumption of operations, the provisions of Article 108.07 shall apply. When the Contractor performs necessary work required to dispose of these materials, payment will be made at the contract unit price for items applicable to such work, or payment shall be made according to Article 104.02.

**107.20 Protection and Restoration of Property.** If corporate or private property interferes with the work, the Contractor shall notify, in writing, the owners of such property, advising them of the nature of the interference and shall arrange to cooperate with them for the protection or disposition of such property. The Contractor shall furnish the Engineer with copies of such notifications and with copies of any agreements between the Contractor and the property owners concerning such protection or disposition.

The Contractor shall take all necessary precautions for the protection of corporate or private property, such as walls and foundations of buildings, vaults, underground structures of public utilities, underground drainage facilities, overhead structures of public utilities, trees, shrubbery, crops, and fences contiguous to the work, for which the contract does not provide for removal or specify precautions. The Contractor shall protect and carefully preserve all official survey monuments, property marks, section markers, and Geological Survey Monuments, or other similar monuments, until the owner, or an authorized surveyor or agent has witnessed or otherwise referenced their location or relocation. The Contractor shall notify the Engineer of the presence of any such survey or property monuments as soon as they are discovered.

The Contractor shall be responsible for the damage or destruction of property of any character resulting from neglect, misconduct, or omission in his/her manner or method of execution or nonexecution of the work, or caused by defective work or the use of unsatisfactory materials, and such responsibility shall not be released until the work shall have been completed and accepted and the requirements of the Specifications complied with.

Whenever public or private property is so damaged or destroyed, the Contractor shall, at his/her expense, restore such property to a condition equal to that existing before such damage or injury was done by repairing, rebuilding, or replacing it as may be directed, or the Contractor shall otherwise make good such damage or destruction in an acceptable manner. If the Contractor fails to do so, the Engineer may, after the expiration of a period of 48 hours after giving the Contractor notice in writing, proceed to repair, rebuild, or otherwise restore such property as may be deemed necessary, and the cost thereof shall be deducted from any compensation due, or which may become due, the Contractor under this or any other contract between the Department and the Contractor.

The Contractor shall remove all mailboxes within the limits of construction which interfere with construction operations and shall erect them at temporary locations.

As soon as construction operations permit, the Contractor shall set the mailboxes at their permanent locations. This work shall be performed as directed by the Engineer. The Contractor shall replace, at the Contractor's expense, any mailbox or post which has been damaged by the Contractor's operations.

The cost of all materials required and all labor necessary to comply with the above Provisions will not be paid for separately, but shall be considered as included in the unit bid prices of the contract, and no additional compensation will be allowed.

**107.21** Protection and Preservation of Aboriginal Records and Antiquities. The Contractor shall take reasonable precautions to avoid disturbing aboriginal records and antiquities of archaeological, paleontological, or historical significance. No objects of this nature shall be disturbed without written permission of the Engineer. When such objects are uncovered unexpectedly, the Contractor shall notify the Engineer of their presence and shall not disturb them until written permission to do so is granted.



If it is determined by the Engineer, in consultation with the Illinois State Museum, that exploration or excavation of aboriginal records or antiquities on land owned or leased by the State is necessary to avoid loss, the Contractor shall cooperate in the salvage work attendant to preservation. If the Engineer determines the salvage work will delay the Contractor's work, an appropriate extension of contract time will be granted.

- 107.22 Environmental Review of Proposed Borrow Areas, Use Areas, and/or Waste Areas. Proposed borrow areas, use areas (including, but not limited to temporary access roads, detours, and runarounds, plant sites and staging and storage areas), and/or waste areas are to be designated by the Contractor to the Engineer and approved prior to their use. A location map showing the size limits of the proposed borrow area, use area, and/or waste area shall be submitted to the Engineer for approval along with an agreement from the property owner granting the Department permission to conduct cultural and biological resource reconnaissance surveys of the site (for archaeological resources, threatened or endangered species or their designated essential habitat, wetlands, prairies, and savannahs). The Engineer will initiate cultural and biological resource reconnaissance surveys of the site, as necessary, at no cost to the Contractor. If the proposed area is within 45 m (150 ft.) of the highway right of way, a topographic map of the proposed site will be required as specified in Article 204.02.
  - (a) Archaeological Resources. If potentially significant archaeological resources are identified, the Contractor shall have the option of choosing another site or paying for additional archaeological testing. If the Contractor chooses the option of additional testing, the Engineer will obtain a time and cost proposal for the Contractor's approval prior to the testing work being done. The archaeological testing may result in three possible conclusions:
    - (1) Results of the tests show that no further archaeological work is warranted and the site is approved, or
    - (2) Results of the test indicate that salvage work is warranted and the

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Contractor shall have the option of selecting another location or paying for the salvage operations, or

(3) Results of the tests indicate the site is of National Register quality and the site cannot be approved.

If the area is approved as a borrow area, use area, and/or waste area, the Contractor shall obtain as part of the agreement with the property owner, the release of ownership of any artifacts found on the site. The agreement shall also provide that such artifacts will become the property of the State of Illinois.

The Contractor shall furnish copies of the proposed and final agreement to the Engineer for approval.

In the event hydraulic fill or commercial material from rock quarries, waste material, etc., is to be used, a reconnaissance survey for archaeological resources will be conducted only if disturbance of previously undisturbed areas is required to provide such material.

- (b) Wetlands. If the results of the biological resource reconnaissance survey indicate wetlands may be adversely affected by the proposed borrow area, use area, and/or waste area, the Engineer shall not approve the area for use unless the Contractor provides documentation of concurrence from the Illinois Department of Conservation in the following:
  - There is no feasible alternative to the proposed action which adversely affects wetlands, and
  - (2) The proposal for use of the area includes all practicable measures to minimize adverse impacts to the wetland and to provide appropriate compensation for any unavoidable adverse impacts.

In addition, when a proposed borrow area, use area and/or waste area may involve the discharge of material into wetlands, the Engineer shall not approve the area for use unless the Contractor provides evidence of necessary permit approval from the U. S. Army Corps of Engineers.

- (c) Threatened and Endangered Species. If the results of the biological resource reconnaissance survey indicate threatened or endangered species or their designated essential habitat may be affected by the proposed borrow area, use area, and/or waste area, the Engineer shall not approve the area for use unless the Contractor provides evidence of compliance with the consultation requirements of the Illinois Endangered Species Protection Act and has received from the Illinois Department of Conservation one of the following findings:
  - The action may promote the conservation of a listed species or its essential habitat, or
  - (2) The action is not likely to jeopardize a listed species or its essential habitat

If the Department of Conservation advises the proposed action may

be likely to jeopardize a listed species or its essential habitat, the Engineer shall not approve the site.

- (d) Forested Areas, Prairies, and Savannahs. If the results of the biological resource reconnaissance survey indicate that forested areas, prairies, or savannahs may be adversely affected by the proposed borrow area, use area, and/or waste area, the Engineer will recommend the Contractor minimize harm to such areas by selecting alternative sites, where practical, and by providing replacement plantings of trees or prairie vegetation, as appropriate. Such plantings may be recommended for the borrow area, use area, and/or waste area, subject to the approval of the property owner, or on highway right of way.
- 107.23 Protection of Streams, Lakes, Reservoirs, Natural Areas, Wetlands, Prairie Areas, Savannahs, and Endangered and Threatened Species. The Contractor shall take sufficient precautions to prevent pollution of streams, lakes, reservoirs, and wetlands with fuels, oils, bitumens, calcium chloride, or other harmful materials. The Contractor shall conduct and schedule operations so as to avoid or minimize siltation of streams, lakes, reservoirs, and wetlands. Where, in the opinion of the Engineer, the land has a high potential for erosion, the areas exposed by construction operations at any one time will be subject to approval by the Engineer, and the duration of the exposure of the uncompleted construction to the elements shall be as short as practicable. Erosion control features shall be constructed concurrently with other work as directed by the Engineer.

The Contractor shall not disturb designated natural areas, wetlands, identified locations where State or Federal-listed endangered or threatened species are known to occur, or areas that have been designated as essential habitat for such species, or prairie or savannah areas where the Department has made commitments for protection of these locations/areas. Also, if previously unidentified natural areas, wetlands, prairies, savannahs, or areas or locations suspected of containing protected species are identified during construction, the Contractor shall not disturb them unless written permission to do so is granted by the Engineer.

If the Engineer determines measures are necessary to mitigate project effects on natural areas, wetlands, prairies, savannahs, protected species, or essential habitat located on land owned or leased by the State, the Contractor shall cooperate in accomplishing these measures. If the Engineer determines such mitigation work for natural areas, wetlands, prairies, savannahs, or endangered and threatened species concerns will delay the Contractor's work, an appropriate extension of contract time will be granted.

**107.24 Forest Protection.** In carrying out work within or adjacent to State or National Forests, the Contractor shall comply with all regulations of the State Fire Marshal, Conservation Commission, Forestry Department, or other authority having jurisdiction governing the protection of forests and the carrying out of work within forests, and shall observe all sanitary laws and regulations with respect to the performance of work in the forest areas. The Contractor shall keep the areas in an orderly condition, dispose of all refuse, obtain permits for the construction and maintenance of all construction camps, stores, warehouses, residences, latrines, cesspools, septic tanks, and other structures according to the requirements of the Forest Supervisor.

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The Contractor shall take all reasonable precaution to prevent and suppress forest fires and shall require employees and subcontractors, both independently and at the request of Forest officials, to do all within their power to prevent and suppress and to assist in preventing and suppressing forest fires and to make every possible effort to notify a Forest official at the earliest possible moment of the location and extent of any fire seen by them.

**107.25 Protection and Restoration of Traffic Signs.** All traffic signs within the limits of construction which interfere with construction operations or which are obscured by or otherwise interfered with by the construction operations to the extent that they no longer have the desired effect on traffic, shall be removed by the Contractor when directed by the Engineer. Any such signs the Engineer determines are essential to the safe and orderly flow of traffic shall be re-erected immediately by the Contractor at temporary locations in a manner approved by the Engineer.

The Contractor shall maintain the signs in a straight and neat condition for the duration of the temporary mounting. Signs which are not to be re-erected immediately shall be stored off the ground in a covered area. As soon as construction operations permit, the signs shall be replaced at their permanent locations to the satisfaction of the Engineer.

Any sign or post which the Engineer determines has been damaged due to the construction operation or while in storage shall be replaced by the Contractor.

The costs of all materials required and all labor necessary to comply with this Provision will be considered as included in the unit bid prices of the contract and no additional compensation will be allowed.

107.26 Indemnification. To the fullest extent permitted by law, the Contractor shall be responsible for any and all injuries to persons or damages to property due to the activities of the Contractor, subcontractors, suppliers, agents, or employees arising out of or resulting from performance of the contract, or any activity in connection therewith. The Contractor shall indemnify and hold harmless the Department, its officers, employees, and agents from any and all claims, lawsuits, actions, costs, and fees (including reasonable attorney fees and expenses) of every nature or description, arising from, growing out of, or connected with the work, or on account of or in consequence of any neglect in safeguarding the work or on account of or in consequence of using unacceptable materials in constructing the work or because of any act or omission, neglect, or misconduct of the Contractor, its officers, employees, agents, its subcontractor, or subcontractors, anyone directly or indirectly employed by them, and/or anyone for whose acts they may be liable or because of any claims or amount recovered by reason of any infringement of any patent, trademark, or copyright or by reason of the violation of any law, ordinance, order or decree. This obligation is binding on the Contractor without regard to whether or not such claim, damage, loss, or expense is caused in part by the act, omission, or negligence of the Department or its officers, employees, or agents.

In claims against the Department or any individual indemnified under this Article by an employee of the Contractor, a subcontractor, anyone directly or indirectly employed by them, or anyone for whose acts they may be liable, the indemnification herein shall not be limited by a limitation on amount or type of damages payable by or for the Contractor or subcontractor under any employee benefits act including but not limited to the Worker's Compensation Act.

In the event any such claim, lawsuit, or action is asserted, any such money due the Contractor under and by virtue of the contract as shall be deemed necessary by the Department for the payment thereof, may be retained by the Department for said purpose, or in case no money or insufficient money is due to satisfy such claim, lawsuit, or action, the Contractor's Surety shall remain liable for any payment therefore until any such lawsuit, action or claim has been settled or has been fully judicially determined and satisfied.

No inspection by the Department, its employees or agents shall be deemed a waiver by the Department of full compliance with the requirements of the contract. This indemnification shall not be limited by the required minimum insurance coverages provided in the contract.

- 107.27 Insurance. The Contractor shall obtain and thereafter keep in force the following insurance coverages provided by insurance companies acceptable to the Department and authorized to transact business under the laws of the State of Illinois. The insurance companies providing coverage shall be rated in the Best's Key Rating Guide. The Department will accept companies with a rating not lower than B+provided the financial size category is VII or larger. Companies rated A- or better shall have a financial size category of not less than VI. Coverage limits shall be written at not less than the minimum specified in this Article. Higher minimum limits and additional coverage may be specified by a special provision elsewhere in the contract. Whether stated in this Article or elsewhere, the Department does not warrant the adequacy of the types of insurance coverage or the limits of liability specified.
  - (a) Workers Compensation and Employers Liability.
    - (1) Workers compensation shall be provided according to the provisions of the Illinois Worker's Compensation Act, as amended. Notwithstanding the rating and financial size categories stated in this Article, coverage may be provided by a group self-insurer authorized in Section 4(a) of the Act and approved pursuant to the rules of the Illinois Department of Insurance.
    - (2) Employers Liability.

a.	Each Accident	\$500,000
b.	Disease-policy limit	\$500,000
C.	Disease-each employee	\$500,000

(b) Commercial General Liability. Required liability insurance coverage shall be written in the occurrence form and shall provide coverage for operations of the Contractor; operations of subcontractors (contingent or protective liability); completed operations; broad form property damage and hazards of explosion, collapse and underground; and contractual liability. The general aggregate limit shall be endorsed on a per project basis.

(1) General Aggregate Limit \$2,000,000

(2) Products-Completed Operations

Aggregate Limit \$2,000,000

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(3) Each Occurrence Limit

\$1,000,000

The coverage shall provide by an endorsement in the appropriate manner and form, the Department, its officers, and employees shall be named as additional insureds with respect to the policies and any umbrella excess liability coverage for occurrences arising in whole or in part out of the work and operations performed. The Department may accept a separate owner's protective liability policy in lieu of the Department, it's officers, and employees being insureds on the Contractor's policies.

(c) Commercial Automobile Liability. The policy shall cover owned, non-owned, and hired vehicles.

Bodily Injury & Property Damage Liability Limit Each Occurrence

\$1,000,000

(d) Umbrella Liability. Any policy shall provide excess limits over and above the other insurance limits stated in this Article. The Contractor may purchase insurance for the full limits required or by a combination of primary policies for lesser limits and remaining limits provided by the umbrella policy.

All insurance shall remain in force during the period covering occurrences happening on or after the effective date and remain in effect during performance of the work and at all times thereafter when the Contractor may be correcting, removing, or replacing defective work until notification of the date of final inspection. Termination or refusal to renew shall not be made without 30 days prior written notice to the Department by the insurer and the policies shall be endorsed so as to remove any language restricting or limiting liability concerning this obligation.

Certified copies of the original policies or certificate(s) of insurance by the insurer(s) issuing the policies and endorsements setting forth the coverage, limits, and endorsements shall be filed with the Department before the Department will execute the contract. A certificate of insurance shall include a statement "the coverage and limits conform to the minimums required by Article 107.27 of the Standard Specifications for Road and Bridge Construction". Any exception or deviation shall be brought to the attention of the Department for a ruling of acceptability. In no event shall any failure of the Department to receive policies or certificates or to demand receipt be construed as a waiver of the Contractor's obligation to obtain and keep in force the required insurance.

All costs for insurance as specified herein will be considered as included in the cost of the contract. The Contractor shall, at its expense and risk of delay, cease operations if the insurance required is terminated or reduced below the required amounts of coverage. Coverage in the minimum amounts set forth herein shall not be construed to relieve the Contractor from its obligation to indemnify in excess of the coverage according to the contract.

107.28 Contractor Safety Responsibility. Nothing in this contract or the contracts between the Department and any construction engineering consultant(s) is intended or shall be construed, unless otherwise expressly stated, to reduce the responsibility of the Contractor, a subcontractor, anyone directly or indirectly

employed by them or anyone for whose acts they may be liable, from full and complete supervision and achievement of work place safety. Any inspection of the work conducted by the Department, the construction engineering consultant(s), and the officers and employees of any of them, whether notice of the results thereof is provided to anyone or not provided to anyone, shall neither establish any duty on their parts nor create any expectation of a duty to anyone, including but not limited to third parties, regarding work place safety.

In order to insure this and other duties of the Contractor certain indemnification and insurance is required by the contract. Additionally, the Contractor guarantees to the Department a safe work place shall be provided for all employees of the Contractor and each of its subcontractors. There shall be no violation by the Contractor, a subcontractor, anyone directly or indirectly employed by them, or anyone for whose acts they may be liable of the applicable standards of the Occupational Safety and Health Act, any other work place safety act of this State, or other work place safety requirement of the Federal Highway Administration if the contract is funded in part with federal funds. The Contractor agrees to require this work place safety guarantee of all subcontractors according to Article 108.01, and expressly to require the Department to be a third party beneficiary of each guarantee.

**107.29 Opening of Section of Highway to Traffic.** The work under construction shall not be opened to traffic until authorized by the Engineer in writing. Whenever, in the opinion of the Engineer, all of the work or any portion thereof is in an acceptable condition for travel, it shall be opened to traffic as may be directed, but such opening shall not be construed as an acceptance of the roadway, or any part of it, or as a waiver of any of the Provisions of the contract.

If the Contractor is dilatory in completing shoulders, drainage structures or other features of the work, the Engineer may order the work opened to traffic, but in such event, the Contractor shall not be relieved of his/her liability and responsibility during the period the work is opened until final inspection.

Whenever the Contractor is required to open to traffic all of the work or any portion thereof according to the authorization of the Engineer given herein, the Contractor shall conduct the remainder of the construction operations so as to cause the least obstruction to traffic and according to the traffic control established in the contract or by the Engineer.

107.30 Contractor's Responsibility for Work. Except as otherwise provided in this Article, all work of the contract, including work added to the contract, shall be under the charge and care of the Contractor. The Contractor shall protect and maintain the work until the date of final inspection provided in writing to the Contractor, by the Department according to Article 105.13. The Contractor shall assume the sole responsibility for risk of loss to the work from or by any cause whatsoever, without regard to its state of completion, and shall rebuild, repair, restore, replace and make good all work to the condition required by the contract.

The provisions of this Article shall not apply to damage caused by traffic on sections not constructed under traffic but, opened to traffic by written order of the Engineer according to Article 107.29 unless the damage was caused in whole or in part by the Contractor's operations or negligence. On sections constructed under traffic, the provisions of this Article shall not apply to damage caused by traffic to facilities existing in the roadway prior to the execution of the contract and to portions

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of the work that have been completed and final inspection has been made by the Engineer according to this Article, unless the damage was caused in whole or in part by the Contractor's operations or negligence or the contract special provisions require the Contractor to protect and maintain existing facilities. For purposes of this Article, sections constructed under traffic shall mean construction or reconstruction on existing roadways and structures where traffic is maintained in whole or in part through and/or within the contract limits.

The Contractor may request in writing he/she be relieved of the responsibility to protect and maintain any portion of the work which is of sufficient size and type it constitutes a functionally whole, stand-alone part of the work, and which has been completed in all respects with the requirements of the contract by requesting final inspection thereof according to Article 105.13. When the road is open to traffic, this request may include, but not be limited to, inspection of completed safety-related hardware items such as impact attenuators, signs, markers, and light standards having traversable, frangible, or breakaway bases; guardrail and terminal sections; and bridge railing at each separate location. The Engineer will in no way be obligated to grant the request as this Article is not intended to create a contractual right to the same, and any approval granted may alter or limit the part of the work subject to the approval. If the Engineer provides written approval, the Contractor shall be relieved of the responsibility to protect and maintain the work subject to the approval and shall not be responsible for the correction of any damage thereto except that caused in whole or in part by Contractor operations or negligence. When damage to the final inspected work occurs and it is determined the Contractor is not responsible, repairs to the work shall be made by the Contractor and payment will be made according to Article 109.04. Repairs to final inspected work required due to defective materials or workmanship or caused in whole or in part by Contractor operations or negligence, shall be performed at the Contractor's expense.

In case of suspension of work from any cause whatever, the Contractor shall be responsible for the project and shall take such precautions as may be necessary to prevent damage to the project, provide for normal drainage and shall erect any necessary temporary structures, signs, or other facilities at the Contractor's expense. During such period of suspension of work, the Contractor shall properly and continuously maintain, in an acceptable growing condition, all living material in newly established plantings, seedings, and soddings furnished under his/her contract, and shall take adequate precautions to protect new tree growth and other important vegetative growth against injury.

**107.31 Contractor's Responsibility for Utility Property and Services.** At points where the Contractor's operations are adjacent to properties of Railroad, telegraph, telephone, and power companies, or are adjacent to other property, damage to which might result in considerable expense, loss, or inconvenience, work shall not be commenced until all arrangements necessary for the protection thereof have been made.

The Contractor shall cooperate with the owners of any underground or overhead utility lines in their removal and rearrangement operations so work may progress in a reasonable manner, duplication of rearrangement work may be reduced to a minimum, and services rendered by those parties will not be unnecessarily interrupted.

In the event of interruption to water or utility services as a result of accidental

breakage or as a result of being exposed or unsupported, the Contractor shall promptly notify the proper authority and shall cooperate with the said authority in the restoration of service. If water service is interrupted, repair work shall be continuous until the service is restored. No work shall be undertaken around fire hydrants until provisions for continued service have been approved by the local fire authority.

Within the State of Illinois, a Joint Utility Locating Information for Excavators (JULIE) System has been established. All utility companies and municipalities which have gas mains and a number of others are a part of this system. The system may also be known as the State-Wide One Call Notice System.

Instead of the Contractor notifying each individual utility owner work will be done in the area, it will only be necessary to call the JULIE number which is (800) 892-0123 and they will notify all member utility companies involved their respective utility should be located. A minimum of 48 hours advance notice is required and the political name of the township where the work is located, as shown on the location map, along with other location information such as land section and quarter section will have to be given.

For utilities which are not members of the JULIE or One Call Notice systems, it will still be necessary to contact the owners directly. The plan general notes will indicate which agencies are members of JULIE and One Call Notice System.

The type of utility and color used for marking are shown in the following table:

Utility Service	<u>Color</u>
Gas, Oil or Petroleum	Yellow
Electric	Red
Communication, Telephone	Orange
Potable Water	Blue
Sewer	Green

**107.32 Furnishing Right of Way.** The Department will make available all necessary rights of way in advance of construction. Any exceptions will be indicated in the contract.

Any temporary easement area shall be used only for the purpose of highway construction for which it was obtained. If the Contractor wishes to use a temporary easement area for such things as equipment and material storage, he/she shall obtain written approval from the property owner involved and present the written approval to the Engineer before using.

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107.33 Personal Liability of Public Officials. In carrying out any of the Provisions of this contract or in exercising any power or authority granted to the Engineer thereby, there shall be no personal liability upon the Engineer or authorized representative, it being understood in such matters they act as agents and representatives of the State. By entering into this contract with the Department, the Contractor covenants and agrees it shall neither commence nor prosecute any action or suit whatsoever against the officers or employees of the Department for any action or omission done or not done in the course of their administration of this contract. The Contractor agrees to pay all attorney fees and all costs incurred by the Department, its officers, and employees on account of action or suit in violation of this Article.

107.34 No Waiver of Legal Rights. The Department shall not be precluded or stopped by final acceptance or final payment, or any measurement, estimate, or certificate made either before or after the completion and acceptance of the work and payment therefore, from showing the true amount and character of the work performed and materials furnished by the Contractor, nor from showing any such measurement, estimate, or certificate is untrue or is incorrectly made; nor the work or materials do not in fact conform to the contract. The Department shall not be precluded or estopped, by final acceptance, final payment, or any measurement, estimate, or certificate and payment in accordance therewith, from recovering from the Contractor or its sureties, or both, such overpayment and damage as it may sustain by reason of the Contractor's failure to comply with the terms of the contract.

A waiver on the part of the Department of any right under the contract or of a breach of any part of the contract shall not be held to be a waiver of any other or subsequent breach or right to enforce any provision of the contract.

**107.35 Construction Noise Restrictions.** All engines and engine driven equipment used for hauling or construction shall be equipped with an adequate muffler in constant operation and properly maintained to prevent excessive or unusual noise.

Construction within 300 m (1000 ft.) of an occupied residence, motel, hospital, or similar receptor shall be confined to the period beginning at 7 A.M. and ending 10:00 P.M. This time regulation shall not apply to sawing contraction joints, as required in Article 420.10, maintenance or operation of safety and traffic control devices such as barricades, signs, and lighting, or to construction of an emergency nature.

Any machine or device or part thereof which is regulated by or becomes regulated by Federal or State of Illinois noise standards shall conform to those standards. Such equipment shall be operated as designated above.

Requests to modify or deviate from these requirements shall be submitted in writing by the Contractor and must be approved in writing by the Engineer.



#### **SECTION 108. PROSECUTION AND PROGRESS**



**108.01 Subletting of Contract.** The Contractor shall not sublet, sell, transfer, assign, or otherwise dispose of the contract or contracts or any portion thereof, or of his/her right, title, or interest therein, without written consent of the Engineer. The

Contractor will be permitted to sublet a portion thereof, but shall perform with the Contractor's own organization, work amounting to not less than 50 percent of the total contract cost, and with materials purchased or produced by the Contractor. Second tier subcontracting will not be allowed. Items designated in the contract as "specialty items" may be performed by subcontract and the cost of any such specialty items so performed by subcontract may be deducted from the total cost before computing the amount of work required to be performed by the Contractor with his/her own organization. "Speciality items" will be those items so designated on the Summary of Quantities included in the plans. The Engineer may request the Contractor provide proof the proposed subcontractor has the experience, ability, and equipment the work requires.

No subcontracts, or assignments of payments due or to become due, shall in any case release the Contractor or surety of liability under the contract and bonds. All transactions of the Engineer shall be with the Contractor. The Contractor shall have a representative on the job at all times when either contract or subcontract work is being performed.

All requests to subcontract shall contain a certification the subcontract agreement exists in writing and physically contains the required Federal and State Equal Employment Opportunity provisions and Labor Compliance provisions, including the contract minimum wage requirements. The Contractor shall permit Department or Federal representatives to examine the subcontract agreements upon notice.

The Engineer may order the Contractor to remove a subcontractor who does not perform satisfactory work. The Contractor shall comply at once and shall not employ the subcontractor for any further work under this contract.

**108.02 Progress Schedule.** After the award of the contract and prior to starting work, the Contractor shall submit to the Engineer a satisfactory progress schedule or critical path schedule which shall show the proposed sequence of work, and how the Contractor proposes to complete the various items of work within the number of working days set up in the contract or on or before the completion date specified in the contract.

This schedule shall be used as a basis for establishing the controlling item of construction operations and for checking the progress of the work. The controlling item shall be defined as the item which must be completed either partially or completely to permit continuation of progress. It shall be the responsibility of the Contractor to show the intended rate of production for each controlling item listed on the schedule during the period such item is controlling.

The Contractor shall confer with the Engineer at regular intervals in regard to the prosecution of the work according to the progress schedule or critical path schedule.

When the contract provides a specified number of working days and at any time the number of working days charged exceeds the proposed working days shown on the approved schedule by 10 working days, the Engineer will select the controlling item of work for the purpose of charging working days. When the contract specifies a completion date and at any time the actual progress is 14 calendar days behind the proposed progress shown on the approved schedule, the Engineer will select the controlling item of work for the purpose of checking the progress of the work. The Engineer will continue to determine the controlling item until the Contractor has submitted a satisfactory revised progress schedule or critical path schedule.

No payment under this contract will be made until a progress schedule has been submitted for approval. Payment may be withheld until a satisfactory schedule has been submitted and approved.

**108.03 Prosecution of the Work.** The Contractor shall begin the work to be performed under the contract not later than 10 days after the execution of the contract by the Department, unless otherwise provided in the contract. The work shall be prosecuted in such a manner and with such a supply of materials, equipment and labor as is considered necessary to ensure its completion according to the time specified in the contract.

The Contractor shall notify the Engineer at least 24 hours in advance of either discontinuing or resuming operations.

**108.04 Working Days.** When the contract provides a specified number of working days or a completion date with a guaranteed number of working days, the charging of working days shall start when the Contractor begins actual construction work, and in no case later than 10 days after the execution and approval of the contract, unless otherwise provided in the contract or directed by the Engineer.

A working day shall be defined as any calendar day between May 1 and November 30 inclusive except Saturdays, Sundays, or legal holidays observed by the Contractor's entire work force in Illinois. The length of a working day will be determined by the Engineer from the number of working hours established by actual job practice by the Contractor for the current controlling item, except not less than 8 hours will be considered in the determination.

A full working day will be charged for any day described in the foregoing on which conditions are such that the Contractor could be expected to do a full day's work on the controlling item. A full working day will be charged on days when the Contractor could be working on a controlling item, but elects not to work, or elects to work elsewhere.

No allowance will be made for delay or suspension of the work due to the fault of the Contractor.

The Engineer will determine which days are workable. One copy of the "Weekly Report of the Resident Engineer" will be mailed to the Contractor's office weekly. Any disagreement with the working day charges shown must be filed in writing with the Engineer within 7 calendar days of receipt of the Report giving detailed reasons for the disagreement. The receipt shall be for purposes of the contract, deemed to occur 3 calendar days after the day of the mailing indicated on the report. The final resolution of such disagreement will be made by the Engineer. By not filing a detailed disagreement within the 7 day period, the Contractor will be deemed to have accepted the report as correct and no further challenge will be allowed.

The basis for charging working days shall be as follows:

- (a) A partial working day of one-quarter, one-half or three-quarters shall be charged under the following conditions:
  - (1) When weather conditions do not permit the completion of a full day's work on the controlling item.
  - (2) When job conditions due to recent weather do not permit full efficiency

#### Prosecution and Progress

of the men or equipment which are working on the controlling item.

- (3) A shortage of help which is beyond the Contractor's control prevents reasonable progress on a controlling item.
- (4) When any condition over which the Contractor has no control prevents completing a full day's production on the controlling item.
- (b) No working day shall be charged under the following conditions:
  - (1) When adverse weather prevents work on the controlling item.
  - (2) When job conditions due to recent weather prevent work on the controlling item.
  - (3) When work has been suspended by an act or an omission of the Department or Engineer.
  - (4) When strikes, lock-outs, extraordinary delays caused by utility and Railroad work, extraordinary delays in transportation, or inability to procure critical materials suspend work on the controlling item, as long as these delays are not due to any fault of the Contractor.
  - (5) When any condition over which the Contractor has no control causes suspension of work on the controlling item.

# 108.05 Completion Date and Completion Date With/Plus Guaranteed Working Days.

- (a) Completion Date. When a completion date is specified, the Contractor shall complete all work subject to the date on or before the specified date.
- (b) Completion Date With Guaranteed Working Days. When a completion date with guaranteed working days is specified, the Contractor shall complete all work on or before the specified completion date or within the number of guaranteed working days, whichever period is the longer.
- (c) Completion Date Plus Guaranteed Working Days. When a completion date plus guaranteed working days is specified, the Contractor shall complete the major items of work as specified in the contract, on or before the completion date. The Contractor shall complete the off the road or miscellaneous items of work within the specified number of guaranteed working days after the completion date.
- **108.06** Labor, Methods, and Equipment. The Contractor shall at all times employ sufficient labor and equipment for prosecuting the several classes of work to full completion in the manner and time required by this contract.

All workers shall have sufficient skills and experience to perform properly the work assigned to them. Workers engaged in special work or skilled work shall have sufficient experience in such work and in the operation of the equipment required to perform all work properly and satisfactorily.

Any person employed by the Contractor or by any subcontractor who, in the opinion of the Engineer, does not perform work in a proper and skillful manner or is intemperate or disorderly shall, at the written request of the Engineer, be removed

at once by the Contractor or subcontractor employing such person, and shall not be employed again in any portion of the work without the approval of the Engineer.

Should the Contractor fail to remove such person or persons as required above, or fail to furnish suitable and sufficient personnel for the proper prosecution of the work, the Engineer may suspend the work by written notice until such orders are complied with.

All equipment which is proposed to be used on the work shall be of sufficient size and in such mechanical condition as to meet requirements of the work and to produce a satisfactory quality of work. Equipment used on any portion of the project shall be such that no injury to the roadway, adjacent property or other highways will result from its use.

When the methods and equipment to be used by the Contractor in accomplishing the construction are not prescribed in the contract, the Contractor is free to use any methods or equipment that can be demonstrated to the Engineer as satisfactory to accomplish the contract work in conformity with the requirements of the contract.

When the contract specifies that the construction be performed by the use of certain methods and equipment, such methods and equipment shall be used unless others are authorized by the Engineer. If the Contractor desires to use a method or type of equipment other than specified in the contract, he/she may request authority from the Engineer to do so. The request shall be in writing and shall include a full description of the methods and equipment proposed to be used and an explanation of the reasons for desiring to make the change. If approval is given, it will be on the condition that the Contractor will be fully responsible for producing construction work in conformity with contract requirements. If, after trial use of the substituted methods or equipment, the Engineer determines that the work produced does not meet contract requirements, the Contractor shall discontinue the use of the substitute method or equipment and shall complete the remaining construction with the specified methods and equipment. The Contractor shall remove the deficient work and replace it with work of specified quality, or take such other corrective action as the Engineer may direct. No change will be made in basis of payment for the construction items involved nor in contract time as a result of authorizing a change in methods or equipment under these Provisions.

108.07 Suspension of Work. The Engineer shall have authority to suspend the work whole or in part, when unsuitable severe weather conditions or other conditions at the site of the work make for circumstances beyond the Contractor's control, which are unfavorable for the satisfactory performance of the work, and when the Contractor does not comply with the contract or orders of the Engineer. Orders to suspend or resume work shall be complied with immediately. If it becomes necessary to stop work for an indefinite period of time, the Contractor shall store all materials in such manner that they will not obstruct or impede the traveling public unnecessarily or become damaged in any way, take every precaution to prevent damage or deterioration of the work performed, provide suitable drainage of the roadway, and erect temporary structures where necessary. The Contractor shall not suspend work without written authority from the Engineer.

The period of suspension shall not count against the time of performance established in the contract unless the suspension is ordered due to the acts or omissions of the Contractor. Extensions of time will be evaluated according to Article 108.08. Except as provided hereinbelow for suspension of an unreasonable duration,

the Contractor shall not be paid additional compensation on account of any suspension ordered pursuant to this Article.

If the performance of all or any portion of the work is suspended or delayed by the Engineer in writing for an unreasonable period of time and the Contractor believes that additional compensation and/or contract time is due as a result of such suspension or delay, the Contractor shall submit to the Engineer in writing a request for adjustment within 7 calendar days of receipt of the notice to resume work. The request shall set forth the reasons and support for such adjustment.

Upon receipt, the Engineer will evaluate the Contractor's request. If the Engineer agrees that the period of suspension was unreasonable and that the cost and/or time required for the performance of the contract has increased as a result of such suspension, the Engineer will make an adjustment (excluding profit) and modify the contract in writing accordingly. In no case shall a suspension of less than 7 calendar days be considered unreasonable. No adjustment will be made for a suspension of any duration, if the suspension was caused by the acts or omissions of the Contractor, subcontractor, suppliers or the weather. The Engineer will notify the Contractor of his/her determination whether or not an adjustment of the contract is warranted.

No contract adjustment will be allowed unless the Contractor has submitted the request for adjustment within the time prescribed. No contract adjustment will be allowed under this clause to the extent that performance would have been suspended or delayed by any other cause, or for which an adjustment is provided for or excluded under any other term or condition of this contract.

#### 108.08 Determination and Extension of Contract Time.

(a) Working Days. When the contract provides a specified number of working days, it is understood that completion of the work within the specified number of working days is an essential part of the contract. The Contractor's plea that insufficient time was specified is not a valid reason for extension of time.

A request for an extension of time may be initiated by either the Engineer or the Contractor. If the Department finds that the quantities of work done, or to be done, are in excess of the estimated quantities by an amount sufficient to warrant additional time, it may grant an extension of time for completion which appears reasonable and proper. The extended number of working days for completion shall then be considered as in effect the same as if it were the original time for completion.

(b) Completion Date. When a completion date is specified, it is understood that time is of the essence and that completion of the work by that date is an essential part of the contract. The Contractor's plea that insufficient time was specified is not a valid reason for extension of time.

When a delay occurs due to unforeseen causes beyond the control and without fault or negligence of the Contractor, including, but not restricted to, acts of God, acts of the public enemy, fires, epidemics, strikes, extraordinary delays caused by utilities or Railroad, extraordinary delays in delivery of materials caused by strikes, lock-outs, wrecks, freight embargoes, governmental acts, inability to procure critical materials and work added to the contract which affects progress on the controlling item,

the time of completion shall be extended in whatever amount is determined by the Department to be equitable.

An "Act of God" means an earthquake, flood, cloudburst, tornado or other phenomena of nature beyond the power of the Contractor to foresee or to make preparation in defense against. A rain, windstorm or other natural phenomenon of normal intensity, based on U.S. Weather Bureau reports, for the particular locality and for the particular season of the year in which the work is being prosecuted, shall not be construed as an "Act of God" and no extension of time will be granted for the delays resulting therefrom. No extension of time will be granted for any delay or suspension of the work due to the fault of the Contractor. No extension of time on account of a delay due to unforeseen causes will be granted if written application therefore is not filed by the Contractor with the Department setting forth the reasons which the Contractor believes will justify the approval of his/her request.

After the Contractor has filed a request for an extension of time, the Department will notify the Contractor, in writing, whether or not such extension will be approved. The Engineer will consider how timely the Contractor prosecuted up to the point of the delay when considering the request. If approved, the extended date for completion shall then be considered as in effect the same as if it were the original date for completion.

(c) Completion Date With a Guaranteed Number of Working Days. When a completion date is specified in a contract which provides a guaranteed number of working days, it is understood that completion of the work by the contract date is an essential part of the contract.

Working days shall be charged as specified in Article 108.04. The guaranteed number of working days may be extended as provided in Article 108.08(a) above.

If the Contractor has not had the guaranteed number of working days available to him/her by the specified completion date, that date may be extended to a date such that the guaranteed number of working days have been available. This date shall then be considered in effect the same as if it were the original date for completion.

108.09 Failure to Complete the Work on Time. Time is of the essence to the contract. Should the Contractor fail to complete the work within the working days stipulated in the contract or on or before the completion date stipulated in the contract or within such extended time as may have been allowed, the Contractor shall be liable and shall pay to the Department the amount shown in the following schedule of deductions, not as a penalty but as liquidated damages, for each day of overrun in the contract time or such extended time as may have been allowed. The liquidated damages for failure to complete the contract on time are approximate, due to the impracticality of calculating and proving actual delay costs. This schedule of deductions establishes the cost of delay to account for administration, engineering, inspection, and supervision during periods of extended and delayed performance. The costs of delay represented by this schedule are understood to be a fair and reasonable estimate of the costs that will be borne by the Department during

#### Prosecution and Progress

extended and delayed performance by the Contractor of the work, remaining incidental work, correction of work improperly completed, or repair of work damaged as a result of the Contractor. The liquidated damage amount specified will accrue and be assessed until final completion of the total physical work of the contract even though the work may be substantially complete. The Department will deduct these liquidated damages from any monies due or to become due to the Contractor from the Department.

# Schedule of Deductions for Each Day of Overrun in Contract Time

	Original Contract Amount		ginal Contract Amount Daily Charge	
	From More	To and	Calendar	Work
	<u>Than</u>	Including	<u>Day</u>	<u>Day</u>
	\$ 0	\$ 25,000	\$ 300	\$ 400
	25,000	100,000	375	500
	100,000	500,000	550	750
	500,000	1,000,000	725	1,000
	1,000,000	2,000,000	900	1,250
	2,000,000	3,000,000	1,100	1,500
	3,000,000	5,000,000	1,300	1,800
	5,000,000	7,500,000	1,450	2,000
	7,500,000	and over	1,650	2,300

When a completion date is specified, the daily charge shall be made for every day shown on the calendar beyond the specified completion date. When the time limit is specified as working days, the daily charge shall be made for each additional working day, computed as specified in Article 108.04.

If contracts are awarded on the basis of a multiple bid, the contract amounts of the individual contracts comprising the multiple bid shall be totaled and the daily charge shall be that required for such total amount.



108.10 Default on Contract. If the Contractor fails to begin the work under contract within the time specified, or fails to perform the work with sufficient workers and equipment or with sufficient materials to ensure the completion of said work within the specified time, or shall perform the work unsuitably, as determined by the Engineer, or shall neglect or refuse to remove materials or perform anew such work as shall be rejected as defective and unsuitable, or shall discontinue the prosecution of the work, or if the Contractor shall become insolvent or be declared bankrupt, or shall commit any act of bankruptcy, or insolvency, or shall make an assignment for the benefit of creditors, or from any other cause whatsoever shall not carry on the work in a manner approved by the Engineer, the Engineer shall give notice in writing to the Contractor and the Contractor's surety of such delinquency, said notice to specify the corrective measures required. If the Contractor, within a period of 10 days after said notice, shall not proceed according to, the Department shall, upon written certificate from the Engineer of the fact of such delinquency and the Contractor's failure to comply with said notice, have full power and authority to forfeit the rights of the Contractor and at its option to call upon the surety to complete the work according to the terms of the contract, or it may take over the work, including any or all materials and equipment on the ground as may be suitable and acceptable, and may complete

the work with its own forces, or use such other methods as, in its opinion, shall be required for the completion of said contract in an acceptable manner.

When the Department calls upon the Surety to complete, the Surety shall enter upon the premises and take possession of all materials, tools, and appliances for the purpose of completing the work under the contract and employ by contract or otherwise any person or persons satisfactory to the Department to finish the work without termination of the contract. Such employment shall not relieve the Surety of its obligations under the contract and the bond. Payments on estimates covering work subsequent to the transfer shall be made to the extent permitted under law to the Surety or its agent without any right of the Contractor to make any claim.



The Contractor shall bear any extra expenses incurred by the State in completing the work, including all increased cost for completing the work, and all damages sustained, or which may be sustained, by the State by reason of such refusal, neglect, failure, or discontinuance of work by the Contractor. After all the work contemplated by the contract has been completed, the Engineer will calculate the total expenses and damages for the completed work. If the total expenses and damages are less than any unpaid balance due the Contractor, the excess will be paid by the Department to the Surety or the Contractor. If the total expenses and damages exceed the unpaid balance, the Contractor and the Surety shall be jointly and severely liable to the Department and shall pay the difference to the Department on demand.

If a notice of termination for default has been issued and it is later determined for any reason that the Contractor was not in default, the rights and obligations of the parties shall be the same as if the notice of termination had been issued pursuant to Termination for Public Convenience in Article 108.12.

- **108.11 Termination of the Contractor's Responsibility.** Whenever the improvements called for by the contract has been completely performed on the part of the Contractor and all parts of the work have been approved by the Engineer and accepted by the Department according to the contract, and the final estimate paid, the Contractor's obligations shall then be considered fulfilled, except those obligations which by their nature extend beyond the completion of work including but not limited to Articles 107.26, 107.27, 107.33 and 107.34.
- **108.12 Termination for Public Convenience.** The Department may, by written order, terminate the contract or any portion thereof after determining that for reasons beyond either Department or Contractor control, the Contractor is prevented from proceeding with or completing the work as originally contracted for, and that termination would, therefore, be in the public interest. Such reasons for termination may include, but need not be necessarily limited to, Executive Orders of the President relating to prosecution of war or national defense, national emergency which creates a serious shortage of materials, orders from duly constituted authorities relating to energy conservation, and restraining orders or injunctions obtained by third-party citizen action resulting from national or local environmental protection laws or where the issuance of such order or injunction is primarily caused by acts or omissions of persons or agencies other than the Contractor.

When contracts, or any portion thereof, are definitely terminated or cancelled, and the Contractor released before all items of work included in his/her contract have been completed, payment will be made for the actual number of units of items of work completed at contract unit prices, or as specified in Article 109.06 for partially completed items, and no claims for loss of anticipated profits shall be considered.

Reimbursement for organization of the work and moving equipment to and from the job will be considered where the volume of the work completed is too small to compensate the Contractor for these expenses under the contract unit prices, the intent being that an equitable settlement will be made with the Contractor.

Acceptable materials, obtained by the Contractor for the work, that have been inspected, tested and accepted by the Engineer, and that are not incorporated in the work may, at the option of the Engineer, be purchased from the Contractor at actual costs as shown by receipted bills and actual cost records at such points of delivery as may be designated by the Engineer.

Termination of a contract, as stated above, will not relieve the Contractor or his/her surety of the responsibility of replacing defective work as required by the contract.

#### **SECTION 109. MEASUREMENT AND PAYMENT**

**109.01 Measurement of Quantities.** All work completed under the contract will be measured by the Engineer according to the United States standard measures. No deduction will be made for fixtures in the roadway having an area of 0.84 m<sup>2</sup> (9 sq. ft.) or less. All measurements for length will be made linearly unless otherwise specified. Longitudinal measurements for areas of base courses, surface courses, pavement and shoulders will be made along the actual surface of the roadway. Transverse measurements for areas of base courses, surface courses, pavements and shoulders, the dimensions used in calculating the pay areas shall be the exact horizontal dimensions shown on the plans, or the dimensions ordered in writing by the Engineer.

The units of measure are metric (English). The units used shall correspond to the units in the contract. The metric units are "hard" converted and an appendix located at the end of the book gives conversion factors for the exact English equivalents.

**109.02 Scope of Payment.** The Contractor shall receive and accept the compensation as herein provided, in full payment for furnishing all materials, labor, tools and equipment; for performing all work contemplated and embraced under the contract; for all loss or damage arising out of the nature of the work and from the action of the elements; for any unforeseen difficulties or obstructions which may arise or be encountered during the prosecution of the work until its final acceptance by the Department; for all risks of every description connected with the prosecution of the work; for all expenses incurred by or in consequence of suspension or discontinuance of such prosecution of the work as herein specified; for any infringement of patents, trademarks or copyrights; and for completing the work in an acceptable manner according to the plans and Specifications.

The payment of any current estimate prior to final acceptance of the work by the Department shall in no way constitute an acknowledgement of the acceptance of the work, nor in any way prejudice or affect the obligation of the Contractor, at his/her own expense, to repair, correct, renew, or replace any defects or imperfections in the construction or in the strength or quality of the materials used in or about the construction of the work under contract and its appurtenances, nor any damage due or attributable to such defects, which defects, imperfections or damage shall have been discovered on or before the final inspection and acceptance of the work. The

Engineer shall be the sole judge of such defects, imperfections or damage, and the Contractor shall be liable to the Department for failure to correct the same as provided herein.

**109.03** Increased or Decreased Quantities. Whenever the quantity of any pay item as given in the proposal shall be increased or decreased, payment shall be made on the basis of the actual quantity completed at the unit price for such pay item named in the proposal, except as otherwise provided in Article 104.02, or in the detailed Specifications for each class of work.

Should any pay items contained in the proposal be found unnecessary for the proper completion of the work, the Engineer may, upon written order to the Contractor, eliminate such pay items from the contract, and such action shall in no way invalidate the contract. When a Contractor is notified of the elimination of pay items, the Contractor will be reimbursed for actual work done and all costs incurred, including mobilization of materials prior to said notification.

**109.04** Payment for Extra Work. Extra work which results from any of the changes as specified in Article 104.02 shall not be started until authorization from the Engineer is received, which authorization shall state the items of work to be performed and the method of payment for each item. Work performed without such order will not be paid for.

Extra work will be paid for at either a lump sum price or agreed unit prices, or on a force account basis.

- (a) Lump Sum Price or Agreed Unit Prices. When extra work is to be paid for at either a lump sum price or agreed unit prices, the lump sum or unit prices shall be agreed upon by the Contractor and the Engineer.
- (b) Force Account Basis. When extra work is to be paid for by force account, the basis for the force account shall be as hereinafter specified.
  - (1) Labor. For all labor and foremen in direct charge of the specific operations, the Contractor shall receive the actual normal rate of wage paid for each and every hour that said labor and foremen are actually engaged in such work.

The Contractor shall receive the actual costs paid to, or in behalf of, workers by reason of subsistence and travel allowances, health and welfare benefits, pension fund benefits or other benefits, when such amounts are required by collective bargaining agreement or other employment contract generally applicable to the classes of labor employed on the work.

An amount equal to 35 percent of the sum of the above items will also be paid the Contractor.

(2) Bond, Insurance, and Tax. For property damage, liability, and workmen's compensation insurance premiums, unemployment insurance contributions and social security taxes on the force account work, the Contractor shall receive the actual cost, to which 10 percent will be added. The Contractor shall furnish satisfactory evidence of the rate or rates paid for such bond, insurance and tax.

#### Measurement and Payment

- (3) Materials. For materials accepted by the Engineer and used, the Contractor shall receive the actual cost of such materials delivered on the work, including transportation charges paid by the Contractor (exclusive of machinery rentals as hereinafter set forth), to which cost 15 percent will be added.
- (4) Equipment. For any machinery or special equipment (other than small tools) the use of which has been authorized by the Engineer, the Contractor shall be paid according to the latest revision of "SCHEDULE OF AVERAGE ANNUAL EQUIPMENT OWNERSHIP EXPENSE" as issued by the Department. The equipment should be of a type and size reasonably required to complete the extra work.
- (5) Miscellaneous. No additional allowance will be made for general superintendence, the use of small tools, or other costs for which no specific allowance is herein provided.
- (6) Statements. No payment will be made for work performed on a force account basis until the Contractor has furnished the Engineer with itemized statements of the cost of such force account work. Statements shall be accompanied and supported by invoices for all materials used and transportation charges. However, if materials used on the force account work are not specifically purchased for such work but are taken from the Contractor's stock, then in lieu of the invoices, the Contractor shall furnish an affidavit certifying that such materials were taken from his/her stock, that the quantity claimed was actually used, and that the price and transportation claimed represent the actual cost to the Contractor.

Itemized statements at the cost of force account work shall be detailed as follows:

- a. Name, classification, date, daily hours, total hours, rate and extension for each laborer and foreman. Payrolls shall be submitted to substantiate actual wages paid if so requested by the Engineer.
- b. Designation, dates, daily hours, total hours, rental rate and extension for each unit of machinery and equipment.
- c. Quantities of materials, prices and extensions.
- d. Transportation of materials.
- Cost of property damage, liability and workmen's compensation insurance premiums, unemployment insurance contributions, and social security tax.
- Work Performed by an Approved Subcontractor. When extra work is performed by an approved Subcontractor, the Contractor shall receive as administrative costs an amount equal to five (5) percent of the first \$10,000 and one (1) percent of any amount over \$10,000 of the total approved costs of such work.





**109.05** Expenses Incurred by the Department. Upon written request of the Engineer, the Contractor shall pay the bills which are the responsibility of the Department. The Contractor shall receive as administrative costs an amount equal to 5 percent of the first \$10,000 and 1 percent of any amount over \$10,000 of the total actual amount so paid out.

**109.06** Payment for Items Omitted When Partially Completed. Should the Department cancel or alter any portion of the contract which results in the elimination or noncompletion of any portions of the work partially completed, the Contractor will be allowed a fair and equitable amount covering all items of work incurred prior to the date of cancellation, alteration or suspension of such work.

The Contractor shall be allowed a profit percentage on the materials used and the construction work actually performed at the rate specified in Article 109.04, but no allowance will be made for any change in anticipated profits. Acceptable materials ordered by the Contractor or delivered on the work prior to the date of its cancellation, alteration or suspension by the Engineer shall be purchased from the Contractor by the Department at actual cost and shall thereupon become the property of the Department; or at the option of the Engineer, the unused acceptable material shall remain the property of the Contractor, and the Contractor shall be paid the actual cost including freight, unloading and hauling costs less the actual salvage value.

**109.07 Partial Payments and Retainage.** At least once each month, the Engineer will make an approximate estimate, in writing, of the materials in place complete, the amount of work performed, and the value thereof, at the contract unit prices. From the amount so determined, a portion of the cost shall be retained according to the following:

- (a) When the awarding authority is the State of Illinois, there shall be deducted 2 percent of the cost of the completed work which shall be retained until after the completion of the entire work to the satisfaction of the Engineer, and the balance certified to the Department for payment. No amount less than \$1000.00 will be approved for payment other than the final payment. The retainage amount will not be reduced below 2 percent until the final payment.
- (b) When the awarding authority is a County or Municipality, there shall be deducted from the amount so determined for the first 50 percent of the completed work a sum of 10 percent to be retained until after the completion of the entire work to the satisfaction of the Engineer. After 50 percent or more of the work is completed, the Engineer may, at his/her discretion, certify the remaining partial payments without any further retention, provided that satisfactory progress is being made, and provided that the amount retained is not less than 5 percent of the total adjusted contract price.

When the principal items of the work have been satisfactorily completed, a semi-final estimate may be made with the consent of the surety. Payment to the Contractor under such an estimate shall not exceed 90 percent of the amount retained after making partial payments, but in no event shall the amount retained after making the semi-final payment be less than 1 percent of the adjusted contract price, nor less than \$500.00.

(c) When the awarding authority is a County or Municipality and any payment

is made directly to the County or Municipality, payments for completed work shall have deducted the proportionate share of the cost to be borne by the awarding authority. The deduction will be the estimated cost to the County or Municipality divided by the awarded contract value with this percentage applied to the value of work in place. Any adjustment to be made because of changed quantities will be made when the final payment is being processed. No retainage will be held from the value of such payments.

In addition, at the discretion of the Department and when evidence satisfactory to the Department is presented, an estimate may be made for payment to include costs which are being incurred in excess of \$10,000 for freight and acceptable reinforcing steel, structural steel, stone, gravel, sand, or any other non-perishable materials delivered on the work or in acceptable storage places and not used at the time of such estimate. The amount thus paid by the Department shall be deducted from estimates due the Contractor as the material is used in the work. If receipted bills for such material and freight are not furnished the Department by the Contractor within 60 days of payment by the Department, the payment will be reclaimed.

At the request of the Contractor, with approval of the Department, the retainage of the contract set forth in this Article may be deposited under a trust agreement with an Illinois Financial Institution of the Contractor's choice and subject to the approval of the Department. The Contractor shall receive any interest thereon. Pursuant to application by the Contractor, a trust agreement by an Illinois Financial Institution and the Department shall contain, as a minimum, the amount to be deposited subject to the trust, the terms and conditions of payment in case of default of the Contractor, and the termination of the trust agreement upon completion of the contract.

The Contractor shall be responsible for obtaining the written consent of an Illinois Financial Institution trustee and any costs or service fees shall be borne by the Contractor. The trust agreement may, at the discretion of the Department and upon request of the Contractor, become operative at the time of the first partial payment according to existing statutes and Department procedures.



As soon as possible after final inspection, the Department will submit final quantities to the Contractor, will request material certification information from the Contractor, and will act on any time extension requests. At the end of 6 months from such action, if the Contractor has not agreed to final quantities or liquidated damages, or submitted required documentation, the Department may withdraw retained funds from the financial institution. At the end of 12 months, the Department may proceed with final payment on the basis of measured quantities.



**109.08** Acceptance and Final Payment. Whenever the improvement provided for by the contract has been completely performed on the part of the Contractor, and all parts of the work have been approved by the Engineer, a final estimate showing the value of the work will be prepared by the Engineer as soon as the necessary measurements and computations can be made, all prior estimates upon which payments have been made being approximate only and subject to correction in the final payment.

Final acceptance occurs by signature on the final estimate and the date of this signature constitutes the acceptance date. Final acceptance shall not constitute acceptance of any unauthorized or defective work or material. The Department shall not be barred from requiring the removal, replacement, repair or disposal of any unauthorized or defective work or material or from recovering damages from any such

work or material.

The amount of this estimate, less any sums that have been deducted or retained under the Provisions of the contract, will be paid to the Contractor as soon as practicable after the final approval of the work, provided the Contractor has furnished to the Department satisfactory evidence that all sums of money due for any labor, materials, apparatus, fixtures or machinery furnished for the purpose of such improvements have been paid, or that the person or persons to whom the same may be due have consented to such final payment.

When the State of Illinois is the awarding authority, unless the Contractor files a claim for adjudication by the Court of Claims according to Article 109.09, the final payment shall constitute a release and waiver of any and all rights and privileges under the terms of the contract, and shall relieve the Department from any and all claims or liabilities for anything done or furnished relative to the work or for any act or neglect on the part of the Department relating to or connected with the contract.

When the county or municipality is the awarding authority, the final payment shall constitute a release and waiver of any and all rights and privileges under the terms of the contract, and shall relieve the Department from any and all claims or liabilities for anything done or furnished relative to the work or for any act or neglect on the part of the Department relating to or connected with the contract.

109.09 Contract Claims. If the Contractor claims that additional payment is due, the Contractor may file a claim according to the requirements specified herein. When the State is the awarding authority, all claims arising under the terms of the contract, which are not disposed of by mutual agreement between the Contractor and the District Engineer, shall be resolved as hereinafter specified. Mutual agreements are subject to the normal administrative approval required for all change orders or authorizations. If written notifications are not given, or if the Engineer is not afforded reasonable access by the Contractor to complete records of actual costs or additional time, or if a claim is not filed according to the procedures and within the time specified herein, then the claim is waived and the Department is released from any and all demands and claims. The fact that the Contractor has provided a proper notification, provided a properly filed claim, or provided the Engineer access to records of actual cost, shall not in any way be construed as proving or substantiating the validity of the claim. If the claim, after consideration by the Engineer, is found to have merit, the Engineer will make an equitable adjustment either in the amount of costs to be paid according to the Basis of Payment specified herein or in the time required for the work or both. If the Engineer finds the claim to be without merit, no adjustment will be made.

The Contractor may present a claim made by a Subcontractor founded upon the terms of the contract or the actions and orders of the Engineer without being first required to make payment to the Subcontractor provided: the Contractor makes written certification that the Subcontractor is entitled to additional compensation; that the Subcontractor will be paid in the event of a favorable resolution of the claim; and that the subcontract, releases and waivers executed by the Subcontractor do not bar payment to the Subcontractor. The written certification may authorize the Subcontractor to present the Subcontractor claim directly to the Department. If such authorization is given, the Contractor need not participate in the verbal presentation of the claim. In any event, the submission shall include a copy of the subcontract, and any releases or waivers signed by the Subcontractor in favor of the Contractor. The Contractor's interest in the Subcontractor's claim shall not be assigned or

otherwise disposed of except as specified in Article 108.01.

- (a) Submission of Claim. All claims filed by the Contractor shall be in writing and in sufficient detail to enable the Engineer to ascertain the basis and amount of the claim. All claims shall be submitted to the District Engineer. As a minimum, the following information must accompany each claim submitted:
  - (1) A detailed factual statement of the claim for additional compensation and time, if any, providing all necessary dates, locations, and items of work affected by the claim.
  - (2) The name of any State official or employee involved in or knowledgeable about the claim.
  - (3) The specific provisions of the contract which support the claim and a statement of the reasons why such provisions support the claim.
  - (4) If the claim relates to a decision of the Engineer which the contract leaves to the Engineer's discretion or as to which the contract provides that the Engineer's decision is final, the Contractor shall set out in detail all facts supporting his/her position relating to the decision of the Engineer.
  - (5) The identification of any documents and the substance of any oral communications that support the claim.
  - (6) Copies of any identified documents, other than State documents and documents previously furnished to the State by the Contractor, that support the claim (manuals which are standard to the industry, used by the Contractor, may be included by reference).
  - (7) If an extension of time is sought, the specific days and dates for which it is sought, the specific reasons the Contractor believes a time extension should be granted, and the specific provisions of Section 108 under which it is sought.
  - (8) If additional compensation is sought, the exact amount sought and a breakdown of that amount into direct labor, direct materials, direct equipment, direct jobsite overhead, and direct offsite overhead.
  - (9) A statement containing the following language:

Under penalty of law for perjury or falsification, the undersigned,				
		, of , (company)		
(name)	(title)	(company)		
hereby certifies that the claim for compensation and time, if any, made herein for work on this contract is a true statement, fully documented and supported under the contract between the parties.				
Dated	/s/			
Subscribed and sworn	day of			
		Notary Public		
My Commission Expires	S			



- (b) Record Retention. It is the responsibility of the Contractor to keep full and complete records of the costs and additional time incurred for any claim. The Contractor shall permit the Engineer to have access to those records and any other records as may be required by the Engineer to determine the facts or contentions involved in the claim. The Contractor shall retain those records for a period of not less than three years after final payment.
- (c) Audit. All claims filed against the State shall be subject to audit at any time following the filing of the claim. The audit may be performed by employees of the State or by an auditor under contract with the State. The audit may begin at any time during the life of the contract, or on 20 calendar days notice to the Contractor or its agents if an audit is to be commenced more than 60 calendar days after the final payment date of the contract. The Contractor, subcontractors, or agents shall provide adequate facilities, acceptable to the Engineer, for the audit during normal business hours. Failure of the Contractor or its agents to maintain and retain sufficient records to allow the auditors to verify all or any portion of the claim or to permit the auditor access to the books and records of the Contractor, subcontractors, or agents shall constitute a waiver of the claim and may bar any recovery of all or any portion thereunder.

The auditors shall have available to them all books and records including but not limited to the following documents:

- (1) Daily time sheets and supervisor's daily reports.
- (2) Union agreements.
- (3) Payroll records including tax, insurance, welfare, and benefits records.
- (4) Material invoices and requisitions.
- (5) Material cost distribution worksheet.
- (6) Equipment records (list of company equipment, rates, etc.).

#### Measurement and Payment

- (7) Vendors', rental agencies, Subcontractors', and agents' invoices.
- (8) Subcontractors' and agents' payment certificates.
- (9) Cancelled checks (payroll and vendors).
- (10) Job cost report.
- (11) Job payroll ledger.
- (12) General ledger.
- (13) Cash disbursements journal.
- (14) Financial statements for all years reflecting the operations on the contract involved.
- (15) Depreciation records on all company equipment.
- (16) If a source other than depreciation records is used to develop costs for the Contractor's internal purposes in establishing the actual costs of owning and operating equipment, all such other source documents.
- (17) All documents, including pricing books and bid documents, which relate to each and every claim together with all documents which support the amount of damages as to each claim.
- (18) Worksheets used to prepare the claim establishing the cost components for items of the claim including but not limited to labor, benefits and insurance, materials, equipment, subcontractors, all documents which establish the time periods, individuals involved, the hours for the individuals, and the rates of the individuals.
- (d) Time of Submission. All claims submitted according to this Article shall be filed not later than 6 months after the Department provides final quantities to the Contractor according to Article 109.07. The 6 months shall run from the date indicated on the final quantities transmittal. The requirement of a general administrative claims cutoff time provided herein shall not constitute a waiver of any notification time requirements stated elsewhere in these specifications or the special provisions.



- Procedure. All claims must be submitted to the District Engineer. The Contractor may request an opportunity to present the claim verbally at each of the following levels if the claim has not been satisfactorily resolved at the previous level.
  - (1) District Engineer
  - (2) Chief, Bureau of Construction
  - (3) Director of Highways

All requests for presentation must be made through the District Engineer. Requests by the Contractor to present a claim at the third level shall be accompanied by two additional copies of the claim with addenda.

For claims between \$50,000 and \$500,000, the Contractor has the option

of presenting third level claims to the Director of Highways (or an appointed Deputy) or to the Department's Construction Contracts Claims Board. The Director of Highways reserves the right to personally review third level claims in excess of \$500,000.

Full compliance by the Contractor with the provisions specified in this Article is a contractual condition precedent to the Contractor's right to seek relief in the Court of Claims. The Director's written response shall be deemed a final action of the Department. Unless the Contractor files a claim for adjudication by the Court of Claims within 60 days after the date of the written response, the failure to so file shall constitute a release and waiver of the claim.

(f) Basis of Payment. After resolution of a claim in favor of the Contractor, any adjustment in time required for the work will be made according to Section 108. Any adjustment in the costs to be paid will be made for direct labor, direct materials, direct equipment, direct jobsite overhead, direct offsite overhead, and other direct costs allowed by the resolution. Adjustments in costs will not be made for interest charges, loss of anticipated profit, undocumented loss of efficiency, prorata home office overhead, unabsorbed overhead and lost opportunity, preparation of claim expenses, and other consequential indirect costs regardless of method of calculation.

The above Basis of Payment is an essential element of the contract and the claim cost recovery of the Contractor shall be so limited.



#### SECTION 200, EARTHWORK, LANDSCAPING, EROSION CONTROL

#### **EARTHWORK**

### SECTION 201. CLEARING, TREE REMOVAL AND PROTECTION, CARE AND REPAIR OF EXISTING PLANT MATERIAL

- **201.01 Description.** This work shall consist of performing the following items wherever they occur within the right of way, or within the limits of construction, including the areas of borrow pits furnished by the Department.
  - (a) Clearing. Clearing shall consist of the removal and disposal of all obstructions such as fences, walls, foundations, buildings, accumulations of rubbish of whatever nature and existing structures, the removal of which is not otherwise provided for in Article 501.05; all logs, shrubs, bushes, saplings, grass, weeds, other vegetation and stumps of less diameter than 150 mm (6 inches).
  - (b) Tree Removal. Tree Removal shall consist of the cutting, grubbing, removal and disposal of trees and stumps, as hereinafter defined.
  - (c) Protection of Existing Plant Material. Protection of existing plant material shall consist of directing work activity away from and protecting trees, shrubs, turf and herbaceous plants on and adjacent to the right of way.
  - (d) Care of Existing Plant Material. Care of existing plant material shall consist of pruning, fertilizing and watering existing plant material to maintain health and vigor during and following construction activity.
  - (e) Repair or Replacement of Existing Plant Material. Repair or replacement of existing plant material damaged by the Contractor shall consist of restoring to original condition specific plant material that was designated to be saved within the limits of construction, or restoring plant material damaged outside the limits of construction.
- **201.02 Definitions.** Tree A woody, perennial plant having a single main stem or trunk, the diameter of which is 150 mm (6 inches) or more at a point 1.3 m (4.5 ft.) above the highest ground level at the base of the tree. Those having a diameter less than 150 mm (6 inches) will be considered saplings. A multiple-stem tree that forks below the 1.3 m (4.5 ft.) point of measurement will be considered a cluster of individual trees. A tree that forks at or above the 1.3 m (4.5 ft.) point of measurement will be considered a single tree.

A tree stump with a diameter at cut off of 150 mm (6 inches) or more will be considered as a tree for purposes of measurement and removal.

Limits of Construction - A boundary line, not necessarily the right-of-way line, extending along each side of the centerline of the improvement as shown on the plans or cross sections; or as designated by the Engineer.

Root Zone - An area around a plant extending at least as far from the base as the longest horizontal branches.

#### **CONSTRUCTION REQUIREMENTS**

**201.03** Removal of Obstructions and Other Materials. All items defined as clearing in Article 201.01(a) shall be removed and disposed of as required by these Specifications.

**201.04 Tree Removal.** Prior to beginning tree removal, all requirements of Article 201.05(a), Protection of Existing Plant Material, shall be completed. All trees except those designated to be saved, and all stumps, shall be cut and disposed of according to Article 202.03. Trees and stumps within the slope limits of embankments 600 mm (2 ft.) or more in depth shall be cut off at ground level. All other trees and stumps within the right of way shall be removed to a depth of not less than 300 mm (12 inches) below the elevation of the subgrade, the finished earth surface or the ground line. Trees of Osage Orange shall not be cut off as specified above, but shall be pulled or grubbed in such a manner as to insure complete removal.

**201.05** Protection of Existing Plant Material. All plant material designated to be saved, or outside of the limits of construction, shall be protected prior to beginning any clearing or removal work and shall remain protected during subsequent construction work.

Parking or maneuvering of machinery, stockpiling of materials or any other use will not be allowed upon unpaved areas within 3 m (10 ft.) of the root zone of trees or plants designated to be protected.

If requested by the Contractor, the Engineer will stake or otherwise mark these protection limits.

- (a) Temporary Fencing. The Contractor shall manually erect a temporary fence as designated on the plans or where directed by the Engineer. The temporary fence shall be similar to plastic or wood lathe snow fence, and shall be a minimum of 1 m (4 ft.) high with stakes placed a maximum of 4.5 m (15 ft.) apart.
- (b) Tree Trunk Protection. The Contractor shall provide 50 mm by 200 mm by 2.4 m (2 inches by 8 inches by 8 ft.) boards banded continuously around each trunk to prevent scarring of trees shown on the plans or designated by the Engineer. For multistem trees, saplings, and shrubs to be protected within the area of construction, temporary fencing may be used for trunk protection.
- (c) Pruning for Safety and Equipment Clearance. All pruning shall be done according to the National Arborist Association's Pruning Standards for Shade Trees Class II Standard pruning specifications. Plant material shall be pruned to provide a minimum vertical clearance of 6 m (20 ft.) from the finished surface of the road bed and shoulders. Pruning for sight distance and other safety purposes shall be as shown on the plans or as directed by the Engineer. Branches on existing plant material to remain that need to be removed for safety or equipment clearance shall be pruned prior to or during the clearing operation. Breaking off branches of plant material to remain during clearing or construction operations will not be allowed.

## Clearing, Tree Removal and Protection, Care and Repair of Existing Plant Material

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- **201.06** Care of Existing Plant Material. If construction is to occur within the root zone of existing plant material, root pruning and special plant care will be required, as hereinafter specified. All pruning shall be performed by a professional arborist (someone whose principal occupation is the care and maintenance of trees).
  - (a) Root Pruning. Root pruning using an approved mechanical root pruning saw shall be performed prior to digging where noted on the plans, or directed by the Engineer. Whenever roots of plant material to remain are exposed during construction, the damaged root ends are to be removed by cutting them off cleanly.

Pruning shall be done in the presence of the Engineer and in such a manner as to preserve the natural growth habit of each plant.

Any damage to the root zone, as determined by the Engineer, shall be compensated by pruning an equivalent amount of the top vegetative growth of the plant material within 1 week following root damage.

The procedure of "drop crotch" pruning shall be employed for all trimming of branches in excess of 50 mm (2 inches) in diameter.

(b) Fertilizer Nutrients. Fertilizer nutrients shall be applied within 48 hours after root damage occurs. A fertilizer with a 1:1:1 ratio shall be applied at the rate of 2 kg (5 lbs.) of nutrients per 90 m<sup>2</sup> (1000 sq. ft.).

Application shall be accomplished by placing dry fertilizer in holes in the soil. The holes shall be 200 to 300 mm (8 to 12 inches) deep and spaced 600 mm (2 ft.) apart in an area beginning 750 mm (30 inches) from the base of the plant. Holes can be punched with a punch bar, dug with a spade, drilled with an auger or any other method approved by the Engineer. Approximately 10 g (0.02 lb.) of fertilizer nutrients shall be placed in each hole [250 holes/90 m² (250 holes per 1000 sq. ft.)].

If the Engineer determines that the hole method of fertilizer placement is not practical or desirable, an approved method of uniform surface application will be allowed.

- (c) Supplemental Watering. In case of inadequate rainfall, as determined by the Engineer, supplemental water shall be applied within 48 hours of any root damage. The water shall be applied at the rate of 9 L/m² (2 gals. per sq. yd.) of surface area within the root zone of plant material having sustained damage to the root zone. Subsequent weekly waterings shall be applied if deemed necessary by the Engineer.
- (d) Tree Pruning. Tree pruning shall consist of pruning branches, for aesthetic and structural enhancement, of existing trees as shown on the plans or as directed by the Engineer. The National Arborist Association's Pruning Standards for Shade Trees Class II - Standard Pruning specifications shall be followed. All branch pruning shall be done between October 15 and April 15, when the trees are dormant.

**201.07** Repair or Replacement of Existing Plant Material. The Contractor shall repair or replace any and all damage, deemed unnecessary by the Engineer to

any existing or newly installed plant material at his/her own expense. Unnecessary damage to ground cover or turf shall be repaired or replaced as specified for restoration of similar areas within the plans, or as directed by the Engineer, and shall be at the Contractor's expense.

All replacement planting under this Article shall conform to the requirements of Section 253 and Article 1081.01; and shall be barerooted, or balled and burlapped according to the transplanting requirements of the plants.

Replacement, if required, shall be as follows:

- (a) Trees. Furnish, deliver, and plant a tree of the same species and variety, and of the same size; or furnish, deliver, and plant at locations designated by the Engineer, a number of saplings of the same species and variety, each having a minimum diameter of 50 mm (2 inches), with the sum of the millimeter (inch) diameters of saplings equaling the millimeter (inch) diameter of the tree to be replaced.
- (b) Shrubs, Small Trees or Evergreens. Furnish, deliver, and plant a plant of the same species and variety, and of the same size in height or width as governed by Article 1081.01(b), Types 1, 2, 3, and 4; or, furnish, deliver and plant at locations designated by the Engineer, a number of plants of the same species and variety whose total measurements shall equal the measurement of the plant to be replaced, measured as above.
- **201.08** Removal of Saplings, Bushes and Roots. Prior to beginning removal of saplings, bushes, and roots, all requirements of Article 201.05 (a) shall be completed. All saplings and bushes, except those designated to be saved, and all roots within the slope limits of embankments 600 mm (2 ft.) or more in depth shall be cut off at the ground level. All other saplings, bushes and roots within the right of way shall be removed to a depth of not less than 300 mm (12 inches) below the elevation of the subgrade, the finished earth surface, or the ground line, and at least below the bottom of the subbase material. Bushes of Osage Orange shall not be cut off as specified above, but shall be pulled or grubbed in such a manner as to insure complete removal.
- **201.09 Disposal of Materials.** Materials shall be disposed of according to Article 202.03.

#### 201.10 Method of Measurement.

- (a) Clearing. Clearing will not be measured for payment.
- (b) Tree Removal.
  - (1) Unit Diameter. Trees to be removed as a payment item, but not measured in hectares (acres), will be measured per unit of diameter where one unit is equal to 25 mm (1 inch). The diameter will be measured at a point 1.3 m (4.5 ft.) above the highest ground level at the base of the tree and will be determined by dividing the measured circumference of the tree by 3.1416. Stumps will be measured at the elevation of cut off. A multiple stem tree's branches having a diameter of 150 mm (6 inches) or more at a point 1.3 m (4.5 ft.) above the highest ground level of at the base of the tree will be measured for

payment as individual trees. The accumulated total number of units will be the pay quantity.

- (2) Hectare (Acre) as Unit.
  - a. Contract Quantities. The requirements for the use of contract quantities shall be according to Article 202.07 (a).
  - b. Measured Quantities. Trees to be removed will be measured by the hectare (acre) when included in the contract as a payment item and shown at definite locations on the plans or staked for removal by the Engineer. The entire area shown on the plans, and directed by the Engineer, will be used in computing the hectares (acres). No deductions will be made for bare areas and existing roads occurring within these limits. Any removal of bushes or saplings within such areas will not be measured separately for payment.
- (3) When it is necessary to remove trees in connection with borrow pits furnished by the Contractor, trees will not be measured for payment.
- (c) Protection of Existing Plant Material.
  - Temporary Fencing. Temporary fencing will be measured for payment in meters (feet) in place.
  - (2) Tree Trunk Protection. Tree trunk protection will be measured for payment as each per tree. A tree with from 1 to 3 stems with one stem having a diameter of 150 mm (6 inches) or more or a sapling shall be measured as 1 tree. Tree trunk protection shall include furnishing, installing and removing this item.
  - (3) Pruning for Safety and Equipment Clearance. Pruning for safety and equipment clearance will not be measured for payment.
- (d) Care of Existing Plant Material.
  - (1) Tree Root Pruning. Tree root pruning will be measured for payment as each per tree. Roots pruned on trees with 1 to 3 stems with one stem having a diameter equal to or greater than 150 mm (6 inches) will be measured as individual items. All pruning, including top pruning necessary to maintain the vigor of the tree, shall be completed prior to measurement for payment.
    - Trimming of roots exposed during excavation will not be measured for payment.
  - (2) Fertilizer Nutrients. Fertilizer will be measured by weight in kilograms (pounds) of actual nutrients used.
  - (3) Supplemental Watering. Supplemental watering will be measured for payment in units of 1000 L (1000 gals.) of water applied to the root zones of plant material.
  - (4) Tree Pruning. Tree pruning for trees and saplings 25 to 250 mm

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(1 to 10 inches) in diameter will be measured for payment as each per tree or sapling. Tree pruning for trees over 250 mm (10 inches) in diameter will be measured for payment as each per tree. Measurement of trunk diameters shall be as specified above in Article 201.10(b)(1).

### 201.11 Basis of Payment.

- (a) Clearing. Clearing will not be paid for separately but shall be considered as included in the excavation required in the contract.
- (b) Tree Removal. Tree removal will be paid for at the contract unit prices per unit diameter for TREE REMOVAL (6 to 15 UNITS DIAMETER), TREE REMOVAL (OVER 15 UNITS DIAMETER), TREE REMOVAL, SPECIAL (6 to 15 UNITS DIAMETER) and TREE REMOVAL, SPECIAL (OVER 15 UNITS DIAMETER); and per hectare (acre) for TREE REMOVAL, HECTARES (ACRES).

If the contract includes a payment item for Tree Removal, Hectares (Acres) but does not include a payment item for Tree Removal, Units Diameter, any tree removal not paid for as Tree Removal, Hectares (Acres), will be paid for according to Article 109.04.

(c) Protection of Existing Plant Material. This work will be paid for at the contract unit price per meter (foot) for TEMPORARY FENCE and at the contract unit price each for TREE TRUNK PROTECTION.

If no pay items have been established in the contract for the protection of existing plant material, this work will be paid for according to Article 109.04.

Pruning for Safety and Equipment Clearance shall be considered as included in Clearing and will not be paid for separately.

(d) Care of Existing Plant Material. This work will be paid for at the contract unit price each for TREE ROOT PRUNING, TREE PRUNING (25 to 250 MILLIMETERS DIAMETER) (1 to 10 INCHES DIAMETER) and TREE PRUNING (OVER 250 MILLIMETERS DIAMETER) (OVER 10 INCHES DIAMETER); at the contract unit price per kilogram (pound) for NITROGEN FERTILIZER NUTRIENTS, POTASSIUM FERTILIZER NUTRIENTS, and PHOSPHORUS FERTILIZER NUTRIENTS; and at the contract unit price per unit for SUPPLEMENTAL WATERING.

Top pruning necessary to maintain the vigor of the tree will not be paid for as a separate item, but shall be included in the bid price for TREE ROOT PRUNING.

If no pay items have been established in the contract for the care of existing plant material, this work will be paid for according to Article 109.04



#### SECTION 202. EARTH AND ROCK EXCAVATION

**202.01 Description.** This work shall consist of the excavation and transportation of suitable excavated material to embankment locations throughout the limits of the contract or the excavation, transportation, and disposal of excavated material. This work does not include excavation for structures or channel excavation.

#### **CONSTRUCTION REQUIREMENTS**

**202.02** Clearing, Tree Removal, and Protection of Existing Plant Material. Prior to starting excavation operations in any area, all clearing, tree removal and protection of existing plant material in that area shall be performed as required in Section 201.

**202.03** Removal and Disposal of Surplus, Unstable, and Unsuitable Materials and Organic Waste. The Contractor, at his/her own expense, shall dispose of all surplus, unstable and unsuitable materials and organic waste, in such a manner that public or private property will not be damaged or endangered.



Suitable earth, stones and boulders naturally occurring within the right of way may be placed in fills or embankments in layers and compacted according to Section 205. Broken concrete without protruding metal bars, bricks, rock, stone, reclaimed asphalt, or uncontaminated dirt and sand generated from construction or demolition activities may be used in embankment or in fill. If used in fills or embankments, these materials shall be placed and compacted to the satisfaction of the Engineer; shall be buried under a minimum of 600 mm (2 ft.) of earth cover (except when the materials include only uncontaminated dirt); and shall not create an unsightly appearance or detract from the natural topographic features of an area. Broken concrete without protruding metal bars, bricks, rock, or stone may be used as riprap as approved by the Engineer. If the materials are used for fill in locations within the right of way but outside project construction limits, the Contractor must specify to the Engineer, in writing, how the landscape restoration of the fill areas will be accomplished. Placement of fill in such areas shall not commence until the Contractor's landscape restoration plan is approved by the Engineer.

Aside from the materials listed above, all other construction and demolition debris or waste shall be disposed of in a licensed landfill, recycled, reused, or otherwise disposed of as allowed by State or Federal solid waste disposal laws and regulations and solid waste determinations of the IEPA.

A permit shall be obtained from IEPA and made available to the Engineer prior to open burning of organic waste (i.e., plant refuse resulting from pruning or removal of trees or shrubs) or other construction or demolition debris. Organic waste originating within the right-of-way limits may be chipped or shredded and placed as mulch around landscape plantings within the right of way when approved by the Engineer. Chipped or shredded material to be placed as mulch shall not exceed a depth of 150 mm (6 inches).

When surplus excavated material is disposed of off the right of way, the Contractor shall obtain and file with the Engineer permission in writing, from the property owner, for the use of the property for this purpose. Any such disposal shall not create an unsightly or objectionable appearance or detract from the natural topographic features, nor be placed at an elevation higher than that of the adjacent roadway without permission from the Engineer.

All unstable and unsuitable material, including excavated material from sewer trenches or other underground construction, shall be excavated or removed and replaced with material acceptable to the Engineer. Unstable and unsuitable material shall not be used in embankments. If unsuitable material is present at or below the finished grade, it shall be removed and replaced with subbase granular material, according to Section 311. Unsuitable material shall be placed or disposed of by the Contractor at his/her own expense outside of the right of way.

**202.04 Classification.** Excavation material will be classified by the Engineer. All excavation will be classified as Earth Excavation, except those materials provided for in Rock Excavation, Excavation for Structures, Channel Excavation, and Rock Excavation in Channel.

Rock Excavation shall consist of the excavation from the roadway of boulders 0.5 m<sup>3</sup> (1/2 cu. yd.) in volume or greater and all rock in ledges, bedded deposits and conglomerate deposits exhibiting the physical characteristics and difficulty of rock removal as determined by the Engineer.

Rock shall be excavated to a minimum of 75 mm (3 inches) below the subgrade of the proposed pavement, surface course or base course and backfilled with subbase granular material to the elevations shown on the plans. The surface of the rock excavation shall be free from projecting points, ribs, crevices or undrained pockets. The method of rock removal shall be the option of the Contractor. However, excessive blasting or overshooting will not be permitted.

**202.05 Drainage.** The excavation shall be maintained so that positive drainage is provided at all times. Ditches and waterways shall be constructed and maintained to the lines, grades and cross sections shown on the plans. The Contractor shall also excavate a ditch at the toe of slope of fills and at the top of slope of cuts at locations designated by the Engineer at the earliest opportunity during construction to control runoff from the embankment or cut section. Material excavated from ditches at the top of slope of cuts shall be placed in a windrow between the ditch and top of slope.

If during the prosecution of the work, it is necessary to interrupt existing sewer or underdrainage to complete contract requirements, temporary drainage facilities shall be provided until the permanent drainage work has been completed. The Contractor shall preserve and protect all existing sewer and drainage facilities within the limits of the contract. The Contractor shall be responsible for all cost associated with the repair of sewer or drainage facilities damaged due to negligence on the Contractor's part.

202.06 Excavation for Base Course Widening and Bituminous Shoulders for Pavement Resurfacing. Excavation for the construction of base course widening and for bituminous shoulders when the existing pavement is not to be widened shall be performed according to the details shown on the plans or as directed by the Engineer. The excavated material shall be used to backfill the remaining portion of the widening trench to the satisfaction of the Engineer after the widening has been constructed and to grade and reshape the shoulders to the new gradeline shown on the plans after the pavement resurfacing has been completed. Backfill shall be completed within 24 hours. The excavated material shall be deposited on the shoulders in such a manner that it will not interfere with drainage or the construction of the base course widening or shoulders and the pavement resurfacing until it can be bladed into final position.

Any surplus excavation not needed for the shoulder reshaping or any unsuitable material shall be disposed of by the Contractor according to Article 202.03.

If sufficient material is not obtained from the excavation for the widening or bituminous shoulder to complete the shoulder grading, the additional material shall be obtained as follows:

(a) From Within the Right of Way. The additional material shall be obtained from ditches within the right of way as directed by the Engineer. The foreslopes, backslopes and ditches in areas from which the additional material is obtained shall be shaped and finished as directed by the Engineer. The longitudinal haul shall not exceed 5 km (3 miles).

If material obtained from the ditches is wet and/or difficult to handle, the Contractor may be required to disc and harrow the shoulder after placement of the material.

(b) From an Outside Source. If additional material is not available within the existing right of way, the Contractor, when authorized by the Engineer, may secure material from a source of his/her own choosing provided the material meets the requirements of Article 204.02.

### 202.07 Method of Measurement.

(a) Contract Quantities. When the project is constructed essentially to the lines, grades, or dimensions shown on the plans and the Contractor and the Engineer have agreed in writing that the plan quantities are accurate, no further measurement will be required and payment will be made for the quantities shown in the contract for the various items involved except that if errors are discovered after work has been started, appropriate adjustments will be made.

When the plans have been altered or when disagreement exists between the Contractor and the Engineer as to the accuracy of the plan quantities, either party shall, before any work is started which would affect the measurement, have the right to request in writing and thereby cause the quantities involved to be measured.

(b) Measured Quantities. Earth and rock excavation will be measured in their original positions, and the volumes in cubic meters (cubic yards) computed by the method of average end areas. The volume of any unstable or unsuitable material removed will be measured for payment in cubic meters (cubic yards).

In rock excavation, the Contractor shall strip ledge rock of overburden so that necessary cross sections for measurement may be taken. Vertical measurements for determining end areas shall extend from the surface of the rock to an elevation not more than 150 mm (6 inches) below the subgrade of the proposed pavement structure, as shown on the plans, or to the bottom of the rock where that point is above the subgrade of the proposed pavement structure. Horizontal measurements for determining end areas shall extend not more than 150 mm (6 inches) beyond the slope lines fixed by the Engineer for the work. Boulders and rocks 0.5 m³ (1/2 cu. yd.) or more in volume will be measured individually and the

volume computed from average dimensions taken in 3 directions.

Subbase granular material used for replacement where rock has been excavated not more than 150 mm (6 inches) below the subgrade of the proposed pavement structure, as shown on the plans, or as directed by the Engineer, will be measured in metric tons (tons) or in cubic meters (cubic yards). The unit of measurement will be shown on the plans. The method of measurement will be according to Article 311.08.

Subbase granular material used for replacement where rock has been excavated more than 150 mm (6 inches) below the subgrade of the proposed pavement structure, will not be measured for payment.

Earth moved more than once due to either stage construction or by written authorization of the Engineer will be measured for payment each time it is moved.

Earthwork required for the construction of base course widening for pavement resurfacing will be measured for payment to the neat lines as shown on the plans and the volume computed in cubic meters (cubic yards). Earthwork required for the construction of bituminous shoulders for pavement resurfacing will be measured for payment in units of 30 m (100 ft.) along each edge of the pavement. Additional material needed to reshape the shoulders that is obtained from within the right of way will be measured for payment as specified above for earth excavation.

**202.08** Basis of Payment. Earth and rock excavation will be paid for at the contract unit prices per cubic meter (cubic yard) for EARTH EXCAVATION and ROCK EXCAVATION, respectively, which prices shall include other items of work included under the general heading of Earthwork for which no payment item is included in the contract.

Subbase granular material will be paid for at the contract unit price per cubic meter (cubic yard) for SUBBASE GRANULAR MATERIAL, TYPE A, or SUBBASE GRANULAR MATERIAL, TYPE B; or at the contract unit price per metric ton (ton) for SUBBASE GRANULAR MATERIAL, TYPE A, or SUBBASE GRANULAR MATERIAL, TYPE B.

When the contract does not contain a unit price for Rock Excavation or Subbase Granular Material, and these items are required, they will be paid for according to Article 109.04.

Earthwork required for the construction of base course widening for pavement resurfacing will be paid for at the contract unit price per cubic meter (cubic yard) for EARTH EXCAVATION (WIDENING), which price shall include the use of the excavated material in backfilling the remaining portion of the trench for pavement widening and in reshaping the shoulders to the new gradeline.

Earthwork required for the construction of bituminous shoulders for pavement resurfacing will be paid for at the contract unit price per unit for EXCAVATING AND GRADING EXISTING SHOULDER, which price shall include the use of the excavated material in reshaping the shoulders to the new grade line.

Additional material required in reshaping the shoulders to the new grade line for

pavement resurfacing that is obtained from within the right of way will be paid for at the contract unit price per cubic meter (cubic yard) for EMBANKMENT, which price shall include any shaping of ditches and slopes and use of the materials in reshaping the shoulders to the new grade line, including any disking and harrowing that may be required. Additional material required in reshaping the shoulders to the new grade line for pavement resurfacing that is obtained from an outside source will be paid for according to Article 109.04.

Temporary drainage facilities required during the course of construction will be paid for according to Article 109.04 unless otherwise provided for in the contract.

# **SECTION 203. CHANNEL EXCAVATION**

**203.01 Description.** Channel excavation shall consist of the removal and satisfactory disposal of all materials encountered in the construction of new stream channels and in widening, deepening or straightening existing stream channels.

### CONSTRUCTION REQUIREMENTS

- **203.02 Classification.** Excavation in channel will be classified as Channel Excavation and Rock Excavation in Channel, according to the provisions of Article 202.04.
- **203.03** Clearing, Tree Removal and Protection of Existing Plant Material. Prior to starting excavation operations, all clearing, tree removal and protection of existing plant material shall be performed as required in Section 201.
- **203.04 Excavation.** The Contractor shall notify the Engineer, at least 3 days in advance of starting excavation operations, to permit the completion of accurate measurements for volume determinations. Any material excavated before such measurements have been taken will not be paid for.

Channels shall be excavated according to the lines, grades and cross sections shown on the plans; there shall be no deviation from the dimensions shown without the written consent of the Engineer. Excavated materials shall be disposed of as shown on the plans or as directed by the Engineer.

Where piles are to be driven as a part of the permanent improvement, any channel excavation at the location of such piles shall be completed to the final elevation before the piles are driven.

- **203.05 Method of Measurement.** Channel Excavation and Rock Excavation in Channel will be measured for payment according to the applicable paragraphs of Article 202.07. The reference to Earth Excavation and Rock Excavation in Article 202.07 shall be construed to include Channel Excavation and Rock Excavation in Channel, respectively.
- **203.06** Basis of Payment. Channel excavation will be paid for at the contract unit prices per cubic meter (cubic yard) for CHANNEL EXCAVATION and ROCK EXCAVATION IN CHANNEL.

When the contract does not contain a unit price for Rock Excavation in Channel and such excavation is required, it will be paid for according to Article 109.04.

#### SECTION 204, BORROW EXCAVATION

**204.01 Description.** Borrow excavation shall consist of excavating suitable materials obtained from locations furnished by the Contractor and transporting the materials to various locations throughout the limits of the contract.

**204.02 Borrow Pits.** The Contractor shall furnish and pay for all borrow sites or other sources of borrow and obtain from the property owners the necessary agreements for the removal of the material. Borrow excavation shall not be placed in the embankment until the site location, excavation plan, and material have been approved by the Engineer in writing. The material used shall have a Standard Dry Density of not less than 1450 kg/m³ (90 lbs. per cu. ft.) when tested according to AASHTO T 99 and shall not possess an organic content greater than 10 percent when tested according to AASHTO T 194.

At the Contractor's option, commercial borrow sites may be used. When commercial borrow sites are used, the following conditions will not be required.

Under no condition shall borrow sites detract from the appearance of the natural topographic features nor increase the potential hazard to a vehicle that has inadvertently left the roadway. In selecting sites for borrow acquisition, preference shall be given to knobs, hills and rises to reduce the extent of pit development. No portion of any borrow pit shall be located within 15 m (50 ft.) or 3 m (10 ft.) plus 1 1/2 times the depth of the excavation, whichever is the greater, from any highway right of way except when borrow is obtained above pavement elevation. In order to ensure an aesthetically acceptable borrow site, the steepest slopes used in excavating borrow shall be 1:4(V:H).

Borrow pits shall not change the general pattern of existing drainage and shall be well drained unless suitable for development as ponds or lakes. Pertinent drainage information shall be shown on the excavation plan or topographic map submitted by the Contractor.

Where the Contractor proposes a borrow site, any portion of which is located within 45 m (150 ft.) of any highway right of way, the Contractor's request for approval shall be accompanied by a topographic map showing the original and the proposed final conditions of the entire borrow site. The topographic map shall be drawn to a minimum horizontal scale of 1:500, and 600-mm (2-ft.) contour intervals shall be indicated.

When a borrow pit is to be developed as a pond or lake, the Contractor shall submit to the Engineer a written statement from the owner that such a development is planned. Slopes of 1:4(V:H) shall be provided along the periphery of the shoreline. Slopes of 1:2(V:H) will be permitted below a point where the proposed water depth will be 2.5 m (8 ft.) or greater. In cases where a dam is necessary to impound water within a borrow pit to be used as a pond, slopes of 1:3(V:H) will be permitted on the water face of the dam. Seeding will not be required below the proposed water elevation.

Borrow sites shall be seeded according to Section 250. The class of seeding and the application rate of fertilizer nutrients and/or ground limestone will be determined by the Engineer. If the proposed borrow site is to revert to agricultural purposes, the Contractor shall submit to the Engineer a written statement from the owner that seeding will not be required. All work in connection with seeding at borrow

sites will not be paid for separately.

After the borrow site excavation is completed, the Contractor shall shape the borrow site to conform to the approved topographic map.

# **CONSTRUCTION REQUIREMENTS**

- **204.03 Clearing, Tree Removal, and Protection of Existing Plant Material.** Before any material is excavated from a borrow pit, clearing, tree removal and protection of existing plant material over the area included within the limits of the pit shall be performed as required in Section 201.
- **204.04 Excavation.** Excavation throughout the borrow pit area shall be as uniform as possible. Upon completion of the excavation operations, all stumps and roots shall be cut off and disposed of as provided in Article 202.03, and the pits shall be trimmed and cleaned.
- **204.05 Method of Measurement.** Borrow excavation will not be measured for payment as a separate item.
- **204.06 Basis of Payment.** Borrow excavation will not be paid for as a separate item, but shall be considered as included in the contract unit price bid for Embankment.

# **SECTION 205. EMBANKMENT**

- **205.01 Description.** This work shall consist of the construction of embankments by depositing, placing, and compacting earth, stone, gravel, or other materials of acceptable quality above the natural ground or other surface.
- **205.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 Materials:

Item	Article/Section
(a) Materials for Settlement Platforms (Note 1	1)
(b) Steel Based Plate	1006.04
(c) Steel Pipe	1006.18
(d) Threaded Malleable Iron Floor Flanges	

- Note 1. All materials furnished to construct settlement platforms will be visually inspected by the Engineer at the job site prior to installation and no other inspection or certification will be required.
- **205.03 Equipment.** Equipment shall meet the requirements of the following Article of Section 1100 Equipment:

	Item	Article/Section
(a)	Disk Harrow	1101.02

#### CONSTRUCTION REQUIREMENTS

**205.04 Preparation of Existing Ground Surface.** Before any embankment is placed, all clearing and tree removal over the entire roadway area shall be performed as provided in Section 201, and the top 150 mm (6 inches) of the existing ground surface shall be disked and then compacted to the satisfaction of the Engineer. Snow and ice shall be removed from the area to be covered by the embankment. Embankment shall not be placed on frozen earth. When construction is resumed after any winter shutdown period, the top 200 mm (8 inches) of all partially completed embankments shall be reprocessed and compacted to the minimum specified density prior to placing more fill material on the embankment.

When embankments are to be constructed on hillsides or slopes, or if existing embankments are to be widened or included in new embankments, the existing slopes shall be plowed deeply. If additional precautions for binding the fill materials together are justified, steps shall be cut into the existing slopes before the construction of the embankment is started.

When embankments are to be constructed over an existing pavement, the following shall govern:

- (a) Flexible Pavement (Aggregate Surface, Bituminous Surface Over Flexible Base). When the surface of the pavement is within 150 mm (6 inches) of the elevation of the subgrade, it shall be plowed, disked, or otherwise broken up to a depth of not less than 150 mm (6 inches).
- (b) Full-Depth and Rigid Pavement (Full-Depth Bituminous Concrete and PCC Pavement), and PCC Base Course.
  - (1) When the distance between the existing pavement and the proposed subgrade is between 75 mm (3 inches) and 1 m (3 ft.), the existing pavement shall be broken into pieces not to exceed 0.3 m<sup>2</sup> (3 sq. ft.) in surface area. At the option of the Contractor, the broken roadway may stay in place unless otherwise directed by the Engineer.
  - (2) When the distance between the existing pavement and the proposed subgrade is less than 75 mm (3 inches), the existing pavement shall be removed.
- **205.05 Placing Material.** Embankment material shall be placed according to the following requirements:
  - (a) General. Embankments shall be constructed of materials that will compact and develop a stability satisfactory to the Engineer. No sod, frozen material or any material which, by decay or otherwise, might cause settlement, shall be placed or allowed to remain in embankments within the area of the roadbed. Embankments shall be constructed to the height and width deemed necessary to provide for shrinkage during compaction. Upon completion, the embankments shall conform to the lines, grades and cross sections shown on the plans. When embankments are constructed of materials specified in Article 202.03, such materials shall be well distributed, and sufficient earth, or other fine material shall be incorporated with them

when they are deposited to fill the interstices and provide solid embankment. No rock, stones or broken concrete more than 100 mm (4 inches) in largest dimension shall be permitted within a vertical distance of 300 mm (12 inches) from the surface of the finished earth grade, or finished earth shoulders. When the contract includes pavement, surface course or base course, the vertical distance may be 75 mm (3 inches) from the finished surface of the subgrade for such construction.

Pieces of concrete, not exceeding  $0.5~\text{m}^2$  (2 sq. ft.) for any area of surface, and large rocks and boulders may be placed in fills without being broken up, provided they are well embedded, and the interstices filled with smaller pieces or smaller material in a manner to give a density satisfactory to the Engineer. The layers of the smaller pieces or smaller material shall not exceed 300 mm (12 inches) in depth.

So far as practicable, each layer of material shall extend the entire length and width of the embankment. The material shall be leveled by means of bulldozers, blade graders or other equipment approved by the Engineer. Each layer shall be not more than 200 mm (8 inches) thick when in loose condition, uniform in cross section, and thoroughly compacted before the next layer is started.

The use of dragline excavators or similar equipment which excavate and deposit material in large unit masses will not be permitted, unless all materials excavated in this manner are spread as provided herein and compacted according to Article 205.06, or as directed by the Engineer.

(b) Adjacent to Structures. When bridges and culverts are not completed in advance of grading operations, an omission in the embankment of not less than 30 m (100 ft.) on each side of each structure shall be made, until such omitted embankment shall be placed later according to the requirements of these Specifications. As an alternate method, an omission in the embankment of sufficient length to permit the completion of the structure and the necessary backfills may be made, provided all backfills and omitted embankments are constructed with granular material furnished and placed at the entire expense of the Contractor. The granular material shall conform to Article 1004.06, and shall be compacted according to Article 205.06.

Embankment behind abutments or around structures shall not be constructed until test specimens show that the concrete has attained a modulus of rupture of 4500 kPa (650 psi), and at least 7 days have elapsed after the completion of the abutment or structure affected. In the absence of tests to determine the modulus of rupture, the minimum length of time between the completion of the abutment or structure and the placing of the embankment shall be at least 14 days exclusive of days in which the temperature falls below 7  $^{\circ}$ C (45  $^{\circ}$ F.).

Embankment, behind abutments held at the top by the superstructure, shall not be placed until the superstructure has been completed and the falsework removed. Embankment, behind such abutments and behind the walls of culverts having a clear height of more than 1.5 m (5 ft.), shall be carried up simultaneously at both ends of the structure, and at no time shall the embankment at one end be more than 600 mm (2 ft.) higher than at

the other.

Backfill shall not be placed in water at closed abutments, culverts or retaining walls. The excavated area around these structures shall be pumped dry, and any mud or loose material within the excavated space shall be removed. Sloping sides of the excavated space shall be removed. Sloping sides of the excavated space, that would be liable to cause objectionable wedging action of the backfill against the structure, shall be stepped or serrated to prevent such action. At piers, backfill may be placed in water, provided that both the water level and backfill are kept at approximately the same elevation on opposite sides of the pier. A time interval, approved by the Engineer, shall elapse before placing additional fill on one side of the pier above the water surface.

A cubical deposit of porous coarse aggregate, at least 600 mm (2 ft.) in each dimension, shall be placed back of each drain hole in abutment and wingwalls and culvert sidewalls. The bottom of this deposit shall be 50 mm (2 inches) below the drain hole. No additional compensation will be allowed for such work. All form boards or other obstructions shall be removed from the drains before the embankment is constructed.

**205.06 Compaction.** Each layer of the embankment material shall be disked sufficiently to break down oversized clods, mix the different materials, secure a uniform moisture content, and ensure uniform density and compaction. Disking may be omitted if the fill material consists of sand or gravel.

If the roadway embankment is less than 450 mm (1 1/2 ft.), all lifts shall be compacted to not less than 95 percent of the standard laboratory density. If the embankment height is between 450 mm and 900 mm (1 1/2 ft. and 3 ft.) inclusive, the first lift shall be compacted to not less than 90 percent, and the balance to a minimum of 95 percent of the standard laboratory density. If the embankment exceeds 900 mm (3 ft.) in height, the lower 1/3 of the embankment, but not to exceed the lower 600 mm (2 ft.), shall be compacted in a manner that will yield a minimum of 90 percent of standard laboratory density to the uppermost lift of that portion of the embankment. The next 300 mm (1 ft.) of embankment shall be compacted to not less than 93 percent, and the balance of the embankment compacted to not less than 95 percent of the standard laboratory density.

The top 600 mm (2 ft.) of all embankments shall not contain more than 120 percent of the optimum moisture determined according to AASHTO T 99 (Method C). The Contractor will be permitted the use of an approved additive to effect a quicker drying time.

The standard laboratory density shall be the maximum density determined according to AASHTO T 99 (Method A or C). A coarse particle correction according to AASHTO T 224 shall be used with Method A and may be used with Method C.

The density of the compacted embankment will be determined by the Engineer at regular intervals according to AASHTO T 191 or AASHTO T 238 and T 239, or by other methods approved by the Engineer.

The embankment shall be sprinkled with water when it is necessary to increase the moisture content of the soil to permit the embankment to be constructed to the densities indicated above. Compacting equipment and compacting operations shall be coordinated with the rate of placing embankment so that the required density is obtained.

Special care shall be exercised in compacting embankments adjacent to structures and in sharp depressions. Where such areas are inaccessible to the compacting equipment being used, the material shall be placed in 200 mm (8 inches) horizontal layers and uniformly compacted with suitable mechanical equipment. Embankment placed adjacent to a structure shall not contain more than 110 percent of the optimum moisture determined according to AASHTO T 99 (Method C).

**205.07 Maintaining and Trimming Embankments.** The Contractor shall replace, at his/her own expense, any portions of the embankment which have been damaged or displaced by reason of carelessness or negligence on the Contractor's part. After the embankments have been constructed, their sides shall be trimmed to the proper slopes where required, and shall be maintained by the Contractor to the proper elevation and cross section until acceptance.

**205.08 Settlement Platforms.** When called for on the plans or should the Contractor desire to request credit for the placement of any additional embankment due to possible settlement during construction, settlement platforms shall be erected at the locations shown on the plans or as directed by the Engineer and as hereinafter specified. Notification of such desire on the part of the Contractor shall be made to the Engineer in writing prior to the start of construction.

The settlement platforms shall be placed on natural soil, where practical, after the roadway area has been cleared, disked and compacted. Compacted granular bedding material up to 150 mm (6 inches) thick may be used to properly seat the platform. Granular material to be used for bedding may consist of any fine aggregate suitable to the Engineer. The subgrade or bedding shall be prepared and leveled in such a manner that the platform makes uniform contact.

A 19-mm (3/4-inch) diameter steel pipe shall be attached to a 3-mm (1/8-inch) thick by 1.2-m (4-ft.) square steel plate with a threaded malleable iron floor flange welded to the plate. 1.2-m (4-ft.) lengths of 19-mm (3/4-inch) diameter pipe shall be added as the height of the embankment increases. The top of the grade pipe shall at no time extend more than 1.4 m (4 1/2 ft.) or less than 150 mm (6 inches).

The Contractor shall exercise extreme caution when placing material adjacent to the settlement plates and no equipment shall pass within 1.5 m (5 ft.) of the settlement plate until the height of fill is 1 m (3 ft.) above the plate in order to maintain a plumb grade pipe.

A casing of 64-mm (2 1/2-inch) diameter steel pipe (standard) shall be installed around the vertical pipe to negate the effect of negative skin friction and to help prevent damage to the grade pipe.

Settlement platforms shall be maintained by the Contractor in the required positions at all times during the construction of the embankment. All movement or disturbance, other than normal settlement, of the settlement platforms shall be immediately corrected by the Contractor by repairing or replacing them as directed by the Engineer. All extensions to the grade pipes shall be added under the supervision of the Engineer.

Settlement readings will be taken by the Engineer as required prior to and after construction of the embankment. The final readings will be taken after the top grade

of the embankment has been constructed and has been approved by the Engineer.

When the settlement platform has served its purpose, the pipe extensions shall be removed to at least 600 mm (2 ft.) below subgrade, the pipe capped, and the area backfilled and compacted.

### 205.09 Method of Measurement.

- (a) Contract Quantities. The use of contract quantities shall conform to the requirements of Article 202.07(a) and to the following:
  - (1) If the Contractor so requests, the Engineer will reestablish the existing ground line after the clearing and tree removal over the entire embankment areas have been performed according to Section 201 and the top 150 mm (6 inches) of the existing ground surface has been disked and compacted to the satisfaction of the Engineer. Contract quantities will be recalculated based on the difference between the existing ground line shown on the plans and the new ground line established after the clearing, disking and compacting.
  - (2) If settlement platforms are erected, the Engineer will reestablish the existing ground line after the embankment is complete from elevations taken on the grade pipes of the settlement platforms. In reestablishing the existing ground line, no change in elevation from that shown on the plan cross sections will be assumed to have occurred at the intersection of the embankment side slopes and the existing ground. Contract quantities will be recalculated based on the difference between the existing ground line shown on the plans and the new ground line established from the settlement platforms.
- (b) Measured Quantities. Embankment will be measured for payment in place and the volume in cubic meters (cubic yards) will be computed by the method of average end areas. Embankment placed in excess of that required for the execution of the contract will not be measured for payment. The volume of embankment will be computed on the basis of using the existing ground line as shown on the plans, except as specified in (1) and (2) below:
  - (1) If the Contractor so requests, the Engineer will reestablish the existing ground line after the clearing and tree removal have been performed according to Section 201 and the top 150 mm (6 inches) of the existing ground surface has been disked and compacted to the satisfaction of the Engineer.
  - (2) If settlement platforms are erected, the Engineer will reestablish the existing ground line after the embankment is complete as specified in Article 205.09(a)(2).
- **205.10** Basis of Payment. Embankment will be paid for at the contract unit price per cubic meter (cubic yard) for EMBANKMENT, which price shall include furnishing, placing and compacting all materials required for embankment construction, including any additive or water applied and settlement platforms.

# SECTION 206. GRANULAR EMBANKMENT, SPECIAL

- **206.01 Description.** This work shall consist of the construction of granular embankment by placing and compacting gravel or crushed stone on an existing pavement or surface course.
- **206.02 Materials.** Materials shall meet the requirements of the following Article of Section 1000 Materials:

	Item	Article/Section
(a)	Granular Embankment, Special (Note 1)	

Note 1. The aggregate shall have a bearing ratio of not less than 80. For crushed gravel, crushed stone, and crushed slag, the bearing ratio requirement shall not apply. The bearing ratio will be determined according to the Standard Methods adopted by the Department.

**206.03 Equipment.** Equipment shall meet the requirements of the following Articles of Section 1100 - Equipment:

	Item	Article/Section
(a)	Tamping Roller	1101.01
	Pneumatic-tired Roller	
	Three-wheel Roller (Note 1)	
(d)	Tandem Roller (Note 1)	1101.01
(e)	Vibratory Machine (Note 2)	



Note 1. The three-wheel or tandem roller shall weigh from 5.5 to 9 metric tons (6 to 10 tons) and shall weigh not less than 35 N/mm (200 lbs. per inch) nor more than 60 N/mm (325 lbs. per inch) of width of the roller.

Note 2. The vibratory machine shall meet the approval of the Engineer.

# **CONSTRUCTION REQUIREMENTS**

**206.04** Placing and Compacting Aggregate. The Contractor shall, at his/her own expense, submit to the Engineer a sample of the aggregate to be used for granular embankment at least 15 days prior to starting construction. The sample so submitted will be tested by the Department for acceptance.

The aggregate shall be placed and compacted according to Article 351.05(a) and (b), except that construction shall be alternated on each lane width so that at no time will there be a difference of more than 100 mm (4 inches) in elevation. Construction operations shall be carried on in such a manner that the elevation of adjacent traffic lanes shall be the same when work is suspended at nights and over weekends or holidays.

**206.05** Construction of Earth Berm. Prior to allowing traffic on the newly constructed layer, the adjacent earth berm shall be built flush with the top of the aggregate and the edges of the aggregate base compacted to the required density. The cost of constructing the earth berm in this manner will be considered as included in the contract unit price bid for Embankment and no additional compensation will be allowed.

- **206.06 Surface Treatment.** Immediately following the final shaping and compacting operation, calcium chloride shall be applied to the surface at the rate of 1 to 2 kg/m² (2 to 4 lbs. per sq. yd.) according to Section 663. After the top layer has been completed, it shall be opened to two-way traffic and shall be maintained by the Contractor for traffic until the entire contract is completed and accepted. In no case shall the maintenance period be less than 10 days. The cost of such maintenance will not be paid for directly, but shall be considered as included in the unit price bid for Granular Embankment, Special, and no additional compensation will be allowed, except that payment will be made for the aggregate and calcium chloride required for maintenance.
- **206.07 Method of Measurement.** Granular Embankment, Special, will be measured for payment in metric tons (tons), or cubic meters (cubic yards) according to Article 311.08. The unit of measurement will be shown on the plans.
- **206.08** Basis of Payment. Granular Embankment, Special, will be paid for at the contract unit price per metric ton (ton) for GRANULAR EMBANKMENT, SPECIAL, or at the contract unit price per cubic meter (cubic yard) for GRANULAR EMBANKMENT, SPECIAL.

The application of calcium chloride will be measured and paid for according to Section 663.

## SECTION 207. POROUS GRANULAR EMBANKMENT

- **207.01 Description.** This work shall consist of furnishing, transporting and placing porous granular material. For the purpose of this specification, the embankment may be above the original ground line, or it may be below the water elevation.
- **207.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 Materials:

	Item Article	e/Section
(a)	Coarse Aggregate	1004.06
(b)	Fine Aggregate	1003.04

### CONSTRUCTION REQUIREMENTS

- **207.03 General.** The aggregate shall be placed in 150 mm (6 inch) layers, loose measurement, and compacted in a manner approved by the Engineer, except that if the desired results are being obtained, the compacted thickness of any layer may be increased to a maximum of 200 mm (8 inches).
- **207.04 Method of Measurement.** Porous Granular Embankment will be measured for payment in metric tons (tons) according to Article 311.08(b), or in cubic meters (cubic yards) compacted in place and the volume computed by the method of average end areas.
- **207.05 Basis of Payment.** This work will be paid for at the contract unit price per metric ton (ton) for POROUS GRANULAR EMBANKMENT, or at the contract unit price per cubic meter (cubic yard) for POROUS GRANULAR EMBANKMENT.

## SECTION 208. TRENCH BACKFILL

**208.01 Description.** This item shall consist of furnishing and transporting fine aggregate for backfilling material for all trenches made in the subgrade of the proposed improvement, and all trenches outside of the subgrade where the inner edge of the trench is closer than 600 mm (2 ft.) to the edge of the proposed pavement, stabilized shoulder, curb, or sidewalk.

This item also includes the disposal of the surplus excavated material which is replaced by trench backfill. Such disposal shall be made according to Article 202.03.

**208.02 Materials.** Materials shall meet the requirements of the following Article of Section 1000 - Materials:

	Item	Article	Section
(a)	Fine Aggregate		1003.04

#### 208.03 Method of Measurement.

- (a) Contract Quantities. The requirements for the use of Contract Quantities shall conform to Article 202.07(a).
- (b) Measured Quantities. Trench backfill shall be furnished for backfilling to the full width of the trench. It will be measured in cubic meters (cubic yards) in place, except that the quantity for which payment will be made shall not exceed the volume of the trench as computed by using the maximum width of trench permitted by the Specifications and the actual depth of the completed trench backfill above the center of the pipe, with a deduction for the volume of one-half of the pipe. Any trench backfill required in excess of the maximum quantity specified shall be furnished by the Contractor at his/her own expense.

Any material meeting the requirements of Article 1003.04 which has been excavated from the trenches shall be used for backfilling the trenches. However, no compensation will be allowed as trench backfill for the portion of the trench backfilled with excavated material.

**208.04** Basis of Payment. This work will be paid for at the contract unit price per cubic meter (cubic yard) for TRENCH BACKFILL.

## SECTION 209. POROUS GRANULAR BACKFILL

- **209.01 Description.** This item shall consist of furnishing, transporting and placing porous granular material for backfilling tile or pipe in trenches.
- **209.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 Materials:

	Item Artic	le/Section
(a)	Coarse Aggregate	. 1004.06
(b)	Fine Aggregate	. 1003.04

#### CONSTRUCTION REQUIREMENTS

**209.03 General.** The porous granular material shall be placed around the tile or pipe for the full width of the trench. This material shall be carried to the top of all water bearing strata intercepted by the trench or to a minimum of 300 mm (1 ft.) above the tile or pipe, as directed by the Engineer. The material shall be placed in layers not exceeding 150 mm (6 inches) in thickness and compacted in a manner approved by the Engineer. The balance of the trench shall be backfilled with approved natural soil.

Surplus excavated material shall be disposed of by the Contractor, at his/her own expense, according to Article 202.03.

- **209.04 Method of Measurement.** Porous granular backfill will be measured in cubic meters (cubic yards) in place, except that the quantity for which payment will be made shall not exceed the volume of the trench as computed by using the maximum width of trench permitted by the Specifications and the actual depth of the completed porous granular backfill above the invert of the pipe, with a deduction for the volume of the pipe. Any porous granular backfill used for the purpose of filling the trench in excess of the maximum quantity specified shall be furnished and placed by the Contractor at his/her own expense.
- **209.05 Basis of Payment.** This work will be paid for at the contract unit price per cubic meter (cubic yard) for POROUS GRANULAR BACKFILL.

### SECTION 210. FABRIC FOR GROUND STABILIZATION

- **210.01 Description.** This work shall consist of furnishing all materials, equipment, and labor, and performing all required operations for the installation of geotechnical fabric in subgrades or as embankment foundations.
- **210.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 Materials:

	Item	Article	/Section
(a)	Geotextile Fabric		1080.02
(b)	Coarse Aggregate (Note 1)		1004.04

Note 1. The course aggregate shall be that specified for Granular Embankment Special.

# **CONSTRUCTION REQUIREMENTS**

**210.03 Installation Requirements.** Fabric shall be delivered to the jobsite in such a manner as to facilitate handling and incorporation into the work without damage. Material shall be stored in such a manner as to prevent exposure to direct sunlight and damage by other construction activities.

Prior to the installation of the fabric, the application surface shall be cleared of debris, sharp objects and trees. Tree stumps shall be cut to the level of the ground

surface. If the stumps cannot be cut to the ground level, they shall be completely removed. In the case of subgrades, all wheel tracks or ruts in excess of 75 mm (3 inches) in depth shall be graded smooth or otherwise filled with soil to provide a reasonably smooth surface.

Fabric may be installed on the application surface either by hand or by mechanical methods, provided that the fabric is not torn or the surface rutted.

Fabric of insufficient width or length to fully cover the specified area shall be lapped, or sewn. The minimum laps for lap only areas are 600 mm (24 inches) and for sewn areas are 100 mm (4 inches). If sewn, the seam strength shall be equal to or exceed the minimum grab tensile strength of the fabric when tested wet.

**210.04 Placement of Granular Blanket.** The granular blanket shall be constructed to the width and depth required on the plans. Granular Embankment Special shall be used in conjunction with the Geotechnical Fabric. The material shall be back dumped on the fabric in a sequence of operations beginning at the outer edges of the treatment area with subsequent placement towards the middle.

Placement of material on the fabric shall be accomplished by spreading dumped material off of previously placed material with a bulldozer blade or endloader, in such a manner as to prevent tearing or shoving of the cloth. Dumping of material directly on the fabric will only be permitted to establish an initial working platform. No vehicles or construction equipment shall be allowed on the fabric prior to placement of the granular blanket.

The granular material shall be placed to the full required thickness and compacted to the satisfaction of the Engineer before any loaded trucks are allowed on the blanket.

Fabric which is damaged during installation or subsequent placement of granular material, due to failure of the Contractor to comply with these provisions, shall be repaired or replaced at the Contractor's expense, including costs of removal and replacement of the granular material.

Torn fabric may be patched in place by cutting and placing a piece of the same fabric over the tear. The dimensions of the patch shall be at least 600 mm (2 ft.) larger than the tear in each direction, and shall be weighted or otherwise secured to prevent the granular material from causing lap separation.

**210.05 Method of Measurement.** Geotechnical Fabric will be measured for payment in place and the area computed in square meters (square yards).

Granular blanket will be measured for payment in metric tons (tons) or in cubic meters (cubic yards) according to Article 311.08. The unit of measurement will be shown on the plans.

**210.06** Basis of Payment. Geotechnical Fabric will be paid for at the contract unit price per square meter (square yard) for GEOTECHNICAL FABRIC FOR GROUND STABILIZATION.

The granular blanket will be paid for at the contract unit price per metric ton (ton) for GRANULAR EMBANKMENT, SPECIAL, or at the contract unit price per cubic meter (cubic yard) for GRANULAR EMBANKMENT, SPECIAL.

### SECTION 211, TOPSOIL AND COMPOST

- **211.01 Description.** This work shall consist of furnishing and placing topsoil, special types of topsoil or compost/topsoil blend.
- **211.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 Materials:

	Item	Article/Section
(a)	Topsoil (Furnished from outside of the R.O.W.)	1081.05
(b)	Compost	1081.05

## CONSTRUCTION REQUIREMENTS

**211.03** Furnishing Topsoil. Topsoil shall be obtained from within the limits of the right of way at the locations and to the depths designated on the plans or approved by the Engineer. This topsoil shall be stockpiled at locations approved by the Engineer. When special types of topsoil are specified, each type shall be handled separately and not allowed to mix with any other material. When special types of topsoil (Hydric, Prairie or Woodland) are specified, the seeds and plants within the excavated special topsoils are desirable to maintain. To keep these seeds and plants viable, the topsoil shall be excavated then placed as directed by the Engineer or as specified in the contract. If stockpiling cannot be avoided, special measures, such as watering the stockpile and planting a cover crop on the stockpile will be required as directed by the Engineer.

If additional topsoil is required to complete the contract to the lines, grades and the minimum thickness shown on the plans, the Contractor shall furnish any additional topsoil from areas outside the limits of the right of way. This additional topsoil obtained from outside the right of way shall be approved by the Engineer prior to its use.

In lieu of furnishing additional topsoil from areas outside the limits of the right of way, the Contractor may request permission to obtain the additional topsoil from areas within the limits of the right of way other than those shown on the plans.

At the Contractor's option or when specified, a blend of topsoil and compost with a maximum of 40 percent compost by volume shall be substituted for the topsoil.

**211.04** Placing Topsoil and Compost. Topsoil or compost/topsoil blend shall not be placed until the area to be covered has been shaped, trimmed and finished according to Section 212. All irregularities or depressions in the surface due to weathering or other causes shall be filled or smoothed out before the topsoil is placed. If the existing surface has become hardened or crusted, it shall be disked or raked or otherwise broken up so as to provide a bond with the layer of topsoil to be applied.

The Engineer will verify that the proper topsoil or compost/topsoil blend depth has been applied. After verification of proper depth, the Contractor shall completely incorporate the placed material into the existing surface to a minimum depth of 150 mm (6 inches) below finished grade by disking or tilling.

**211.05** Finishing. The surface of the topsoil or compost/topsoil blend shall be free from clods, stones, sticks and debris and shall conform to the lines, grades and the minimum thickness shown on the plans. If required by the Engineer, one rolling

of the entire surface shall be made.

**211.06** Clearing Area and Disposal of Surplus Material. Upon completion of the work, all areas shall be cleared of equipment, debris, and excess material. Surplus or waste material resulting from construction operations shall be disposed of by the Contractor according to Article 202.03.

#### 211.07 Method of Measurement.

- (a) Contract Quantities. The requirements for the use of contract quantities shall conform to Article 202.07(a).
- (b) Measured Quantities. Furnishing and placing topsoil and special types of topsoil will be measured for payment in place and the area computed in square meters (square yards). When the use of compost is required, furnishing and placing compost will be measured for payment in place and the area computed in square meters (square yards). Compost used at the Contractor's option will not be measured for payment, but will be considered as part of the specified thickness of topsoil.
- **211.08 Basis of Payment.** Furnishing and placing topsoil will be paid for at the contract unit price per square meter (square yard) for FURNISHING AND PLACING TOPSOIL or FURNISHING AND PLACING TOPSOIL (SPECIAL TYPES), of the thickness specified.

When the use of compost is required, furnishing and placing compost will be paid for at the contract unit price per square meter (square yard) for FURNISHING AND PLACING COMPOST, of the thickness specified.

The above prices shall include furnishing topsoil and special types of topsoil, stock piling when necessary, furnishing compost, hauling and placing the topsoil or topsoil and compost at the locations and to the thicknesses shown on the plans, disking or tilling, finishing and rolling if required.

# SECTION 212. FINAL SHAPING, TRIMMING AND FINISHING

**212.01 Description.** This work shall consist of the final shaping, trimming, and finishing of the roadway, the final finishing and cleaning up of the right of way, and completing the work for acceptance. This work is in addition to the requirements of Article 104.06.

# CONSTRUCTION REQUIREMENTS

**212.02 Grading Sections.** When the contract does not include a surface or base course, the ditches shall be cleaned, all irregularities in the roadbed shall be smoothed out, depressions shall be filled, and the entire roadway shall be shaped, trimmed and finished uniformly to the lines, grades and cross sections shown on the plans, and the right of way cleaned up for final acceptance. The finished surface of the roadbed shall not vary from the lines, grades, and cross sections shown on the plans by more than 50 mm (2 inches).

# Final Shaping, Trimming and Finishing

- 212.03 Full Depth and Rigid Type Surface Sections. The roadway for concrete pavement, full-depth bituminous concrete, or pavement with concrete base course and any bituminous surface course shall be shaped, trimmed and finished as follows:
  - (a) Sections Not Previously Graded. The ditches shall be cleaned, and the entire roadway shall be shaped, trimmed and finished uniformly to the lines, grades, and cross sections shown on the plans, and the right of way cleaned up for final acceptance.
  - (b) Sections Previously Graded. Where it is not necessary to secure material from the backslopes of cuts and ditches to complete the earthwork in the roadbed; or where no work is indicated on the plans which will interfere with such slopes; or where the Contractor's operations do not disturb such slopes, no further work on the slopes will be required. If such slopes are disturbed by the Contractor's operations, the Contractor shall trim and reshape them in a manner satisfactory to the Engineer.

In reshaping existing shoulders and medians, widening existing embankments, or raising existing low shoulders and medians, the Contractor shall construct or reshape the shoulders and medians according to Section 480.

Side slopes of fills shall be trimmed and shaped for a distance of 1.2 m (4 ft.), measured from the edge of the shoulder toward the toe of the fill slope. The ditches shall be cleaned, and the right of way cleaned up for final acceptance.

- **212.04 Nonrigid Type Surface and Base Course Sections.** The roadway for nonrigid type surfacings, such as aggregate surface course or any bituminous surface course not built on a portland cement concrete base course, shall be shaped, trimmed and finished as follows:
  - (a) General. After the surface or base course material has been placed, all additional construction operations shall be performed in such a manner that earth or other objectionable substances will not be deposited on the surface or base course material.
  - (b) Sections Not Previously Graded. Where the trench method of constructing the surface or base course is required, all final shaping, trimming and finishing of ditches, backslopes of cuts and sideslopes of fills shall be completed to the lines, grades and cross sections shown on the plans, and all shoulder material shall be roughed in before the surface or base course material is placed.
    - Where the trench method of constructing the surface course is not required, all final shaping, trimming, and finishing of the roadbed shall be completed to the lines, grades and cross sections shown on the plans, before the surfacing material is placed.
  - (c) Sections Previously Graded. The backslopes of cuts and ditches and the sideslopes of fills shall be finished as provided in Article 212.03(b) before the surface or base course material is placed.

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Where the trench method of constructing the surface or base course is required, all shoulder material shall be roughed in before the surface or base course material is placed.

Where the trench method of constructing the surface course is not required, all final shaping, trimming and finishing of the roadbed shall be completed before the surfacing material is placed.

**212.05 Finishing.** All unsuitable material, debris, and rubbish, resulting from construction operations, or occurring within the right of way, and all stones or boulders more than 75 mm (3 inches) in largest dimension, shall be removed from the right of way and disposed of by the Contractor according to Article 202.03. The degree of finish for graded slopes outside of the roadbed shall be that which can be obtained by use of suitable mechanical equipment, with only such hand labor as special conditions may require.

Where the roadway has been resurfaced and as directed by the Engineer, any high areas in the existing earth shoulders that remain after resurfacing is complete which would entrap water adjacent to the pavement edge shall be bladed off. The existing earth shoulders shall be sloped to drain, but grading which requires additional material to conform to a uniform cross section will not be required.

Immediately prior to final inspection, mowing of the right of way will be required at locations as directed by the Engineer.

**212.06 Basis of Payment.** Except for blading off high spots in the existing earth shoulders where the roadway has been resurfaced and for mowing immediately prior to final inspection, this work will not be measured or paid for separately, but shall be considered as included in the contract unit price for the particular type of surface course, base course or widening included in the contract. If surface course, base course or widening items are not included in the contract, the cost of final shaping, trimming and finishing shall be considered as included in the contract unit prices for the various items of earthwork.

Blading off high spots in the existing earth shoulders where the roadway has been resurfaced and mowing required immediately prior to final inspection will be paid for according to Article 109.04.

## **SECTION 213. EXPLORATION TRENCH**

**213.01 Description.** This item shall consist of constructing a trench for the purpose of locating existing farm underdrains within the construction limits of the proposed improvement.

### CONSTRUCTION REQUIREMENTS

**213.02 General.** The exploration trench shall be constructed at the locations shown on the plans or as directed by the Engineer.

The trench shall be not less than 1.3 m (52 inches) in depth, measured from the existing ground elevation. The width of the trench shall be sufficient to allow proper

investigation of the entire trench.

When an existing farm underdrain is encountered, another trench shall be excavated on the opposite side of the proposed improvement to establish the line and grade of the existing farm underdrain. Broken tile shall be repaired immediately and no surface runoff shall be allowed to enter any tile.

After the trench has been inspected by the Engineer, the excavated material shall be used to backfill the trench in a manner satisfactory to the Engineer. Any excess material shall be disposed of according to Article 202.03, and the area shall be shaped and trimmed according to Section 212.

When approved by the Engineer, the Contractor may use other means of locating existing farm underdrains.

- **213.03 Method of Measurement.** The exploration trench will be measured for payment in meters (feet) of actual trench constructed.
- **213.04 Basis of Payment.** This work will be paid for at the contract unit price per meter (foot) for EXPLORATION TRENCH, of the depth specified, which price shall include backfilling the trench and the replacement of broken tile.

Other means of locating existing farm underdrains approved by the Engineer, will be paid for according to Article 109.04.

#### LANDSCAPING

### **SECTION 250. SEEDING**

- **250.01 Description.** This work shall consist of preparing the seed bed and placing the seed and other materials required in the seeding operations on the shoulders, slopes, and other areas.
- **250.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 Materials:

	Item Artic	cle/Section
(a)	Seeds	1081.04
(b)	Agricultural Ground Limestone	1081.07
(c)	Fertilizer	1081.08

**250.03 Equipment.** Equipment shall meet the requirements of the following Articles of Section 1100 - Equipment:

	ltem .	Article/Section
(a)	Disk	1101.08(a)
(b)	Slope Harrow	1101.08(b)
(c)	Hydraulic Seeder	1101.08(c)
(d)	Cultipacker	1101.08(d)
(e)	Spinning Disk Seeders	1101.08(e)
(f)	Tractor Drawn or Mounted Seeders	1101.08(f)
(g)	Rangeland Type Grass Drill and	
	Interseeding Attachment	1101.08(g)
(h)	Slit Seeder	1101.08(h)

### **CONSTRUCTION REQUIREMENTS**

**250.04** Fertilizer and Agricultural Ground Limestone Application. When specified for bare earth areas, fertilizer nutrients and agricultural ground limestone shall be uniformly spread over the designated areas immediately prior to seed bed preparation.

When specified for existing turf areas, fertilizer nutrients and agricultural ground limestone shall be uniformly spread over the designated areas during the spring, late summer or early fall seasons. The Contractor will be required to restore, at his/her expense, any existing turf areas damaged by improper application of fertilizer nutrients or agricultural ground limestone.

When fertilizer is specified, 300 kg (270 lbs.) of fertilizer nutrients per hectare (acre) shall be applied at 1:1:1 ratio as follows:

Nitrogen Fertilizer Nutrients	100 kg/ha (90 lbs./acre)
Phosphorus Fertilizer Nutrients	100 kg/ha (90 lbs./acre)
Potassium Fertilizer Nutrients	100 kg/ha (90 lbs./acre)

When agricultural ground limestone is specified, 4.5 metric tons/ha (2 tons per acre) shall be applied.

Art. 250.05 Seeding

**250.05 Seed Bed Preparation.** For bare earth seeding, seed bed preparation shall not be started until all stones, boulders, debris and similar material larger than 75 mm (3 inches) in diameter have been removed and all other requirements of Section 212 have been completed. The area to be seeded shall be worked to a minimum depth of 75 mm (3 inches) with a disk tiller or other equipment approved by the Engineer, reducing all soil particles to a size not larger than 50 mm (2 inches) in the largest dimension. The prepared surface shall be relatively free from all weeds, clods, stones, roots, sticks, rivulets, gullies, crusting and caking. No seeds shall be sown until the seed bed has been approved by the Engineer.

Seed bed preparation will not be required for Class 7 Seeding if the soil is in a loose condition. Light disking shall be done if the soil is hard or caked.

Selective mowing stakes shall be installed to delineate areas to be seeded or interseeded with Class 4 or 5 mixtures. Selective mowing stakes shall be steel posts as described in Article 1081.11. The selective mowing stakes shall be driven into the ground to a height of 1.1 m (3 1/2 ft.) above the ground at locations shown on the plans and as directed by the Engineer.

250.06 Seeding Methods. No seed shall be sown during high winds or when the ground is not in a proper condition for seeding, nor shall any seed be sown until the purity test has been completed for the seeds to be used, and shows that the seed meets the noxious weed seed requirements. The seeding dates for mixture Classes 4 and 5 shall be from May 15 to June 30 and from October 15 to December 1. All equipment shall be approved by the Engineer prior to being used. Prior to starting work, seeders and interseeders shall be calibrated and adjusted to sow seeds at the required seeding rate. Equipment shall be operated in a manner to ensure complete coverage of the entire area to be seeded or interseeded. The Engineer shall be notified 48 hours prior to beginning the seeding operations so that the Engineer may determine by trial runs that a calibration of the seeder will provide uniform distribution at the specified rate per hectare (acre). When seed or fertilizer is applied with a hydraulic seeder, the rate of application shall be not less than 9500 L (1000 gals.) of slurry per hectare (acre). This slurry shall contain the proper quantity of seed or fertilizer nutrients specified per hectare (acre). When using a hydraulic seeder, the fertilizer nutrients and seed shall be applied in 2 separate operations.

All legumes (clover, vetch, birdsfoot trefoil, lespedeza and alfalfa) shall be inoculated with the proper bacteria in the amounts and manner recommended by the manufacturer of the inoculant before sowing or being mixed with other seeds for sowing. The inoculant shall be furnished by the Contractor and shall be approved by the Engineer. The seed shall be sown as soon as possible after inoculation. Seed that has been standing more than 24 hours after inoculation shall be reinoculated before sowing. If legumes are applied by a hydraulic seeder, 3 times the normal amount of inoculant shall be used.

- (a) Bare Earth Seeding. Bare earth seeding shall be done using the following methods unless otherwise specified or directed by the Engineer:
  - (1) Seeding Classes 1, 2, and 6 shall be sown with a machine that mechanically places the seed in direct contact with the soil, packs and covers the seed in one continuous operation.
  - (2) Seeding Class 4 shall be sown with a rangeland type grass drill.
- (3) Seeding Class 3 shall be sown with a hydraulic seeder.

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(4) Seeding Class 5 shall be sown with a hydraulic seeder or rangeland type grass drill.

Broadcasting or hydraulic seeding will be allowed as approved by the Engineer on steep slopes (over 1:3 (V:H)) or in inaccessible areas where use of the equipment specified is physically impossible. When Seeding Class 7 is used as a temporary erosion control measure to establish temporary cover, hand broadcasting of the seed or other methods approved by the Engineer will be allowed.

(b) Interseeding. Interseeding is the seeding of areas of existing turf. Prior to interseeding, all areas of existing turf to be interseeded except as listed below shall be mowed one or more times to a height of not more than 75 mm (3 inches). The equipment used shall be capable of completely severing all growth at the cutting height and distributing it evenly over the mowed area. The cut material shall not be windrowed or left in a lumpy or bunched condition. Subsequently, mowing may be required, as directed by the Engineer, on certain areas in order to disperse the mowed material and allow penetration of the seed. The Contractor will not be required to mow within 300 mm (1 ft.) of the right-of-way fence, continuously wet ditches and drainage ways, slopes 1:3 (V:H)) and greater, or areas which may be designated as not mowable by the Engineer.

Debris encountered during the mowing and interseeding operations which hamper the operation or are visible from the roadway shall be removed and disposed of according to Article 250.05. Damage to the right of way and turf, such as ruts or wheel tracks more than 50 mm (2 inches) in depth, shall be repaired to the satisfaction of the Engineer prior to the time of interseeding.

All seeding classes shall be interseeded using a rangeland type grass drill with an interseeding attachment, except:

- (1) When specified in the plans or directed by the Engineer, a slit seeder shall be used to interseed Class 1 or Class 2 seed.
- (2) Broadcasting or hydraulic seeding will be allowed as approved by the Engineer on steep slopes (over 1:3 (V:H)) or in inaccessible areas where use of the equipment specified is physically impossible. Sufficient water shall be applied to these areas to wash the seed down to the soil.

**250.07 Seeding Mixtures.** The classes of seeding mixtures and combinations of mixtures will be designated in the plans.

When more than one seeding mixture is specified for an area, all the permanent seeding mixtures must be applied separately, but within the same week. When a temporary mixture is included in the mixtures to be applied to an area, the Class 7 mixture can be applied at any time prior to applying the permanent mixtures or added to the seed mixture and applied with a permanent mixture.

# Seeding

Table 1 - SEEDING MIXTURES			
CLA	SS - TYPE	SEEDS K	G/HECTARE(LBS./ACRE)
1	Lawn Mixture	Ky Bluegrass Perennial Ryegrass Creeping Red Fescue	55 (50) 35 (30) 25 (20)
1A	Salt Tolerant Lawn Mixture	Bluegrass Perennial Ryegrass Dawsons Red Fescue Scaldis Hard Fescue Fults Salt Grass*	35 (30) 10 (10) 10 (10) 10 (10) 35 (30)
1B	Low Maintenance Lawn Mixture	Fine Leaf Turf-Type Fescue Perennial Ryegrass Creeping Red Fescue	e 3/ 170 (150) 35 (30) 25 (20)
2	Roadside Mixture	Alta Fescu or Ky 31 Perennial Ryegrass Creeping Red Fescue Oats, Spring	55 (50) 35 (30) 25 (20) 55 (48)
2A	Salt Tolerant Roadside Mixture	Alta Fescue or Ky 31 Perennial Ryegrass Dawsons Red Fescue Scaldis Hard Fescue Fults Salt Grass 1/	35 (30) 10 (10) 10 (10) 10 (10) 35 (30)
3	Slope Mixture	Alta Fescue or Ky 31 Perennial Ryegrass Alsike Clover 2/ Birdsfoot Trefoil 2/ Andropogon Scoparius (Little Bluestem) Bouteloua Curtipendula (Side-Oats Grama) Fult Salt Grass 7/ Oats, Spring	45 (40) 25 (20) 5 (5) 10 (10) 5 (5) 10 (10) 35 (30) 55 (50)
4	Native Grass	Andropogon gernadi (Big Blue Stem) Andropogon scoparius (Little Blue Stem) Boutelova curtipendula (Side-Oats Grama) Elymus canadensis (Wild Rye) Panicum virgatum (Switch Grass) Sorghastrum nutons (Indian Grass) Annual Ryegrass Oats, Spring Perennial Ryegrass	4 ( 4) 5 ( 5) 5 ( 5) 1 ( 1) 1 ( 1) 2 ( 2) 30 (25) 30 (25) 15 (15)

	9	
CLASS - TYPE	SEEDS	KG/HECTARE(LBS./ACRE)
4A Low Profile Native Grass	Andropogon scoparius (Little Blue Stem) Boutelova curtipendula (Side-Oats Grama) Elymus canadensis (Wild Rye) Sporobolus heterolepsis	5 ( 5) 5 ( 5) 1 ( 1)
	(Prairie Dropseed) Annual Ryegrass Oats, Spring Perennial Ryegrass	0.5 (0.5) 30 (25) 30 (25) 15 (15)
4B Wetland Grass and Sedge Mixture	Annual Ryegrass Oats, Spring Wetland Grasses (Below	30 (25) 30 (25) 6 (6)
<u>Species</u>	% By W	/eight 5/
Calamagrostis canad (Blue Joint Grass)		-
Carex lacustris (Lake-Bank Sedge	) 6	3
Carex slipata (Awl-Fruited Sedge	e) 6	3
Carex stricta (Tussock Sedge)	6	3
Carex vulpinoidea (Fox Sedge)	6	3
Eleocharis aciculoris (Needle Spike Rus	h) 2	2
Elecocharis obtusa (Blunt Spike Rush)	2	2
Glyceria striata (Fowl Manna Gras	s) 14	ļ.
Juncus effusus (Common Rush)	6	3
Juncus tenuis (Slender Rush)	6	3
Juncus torreyi (Torrey's Rush)	6	3
Leersia oryzoides (Rice Cut Grass) Scirpus acutus	10	)
(Hard-Stemmed Bu Scirpus atrovirens	ulrush) 2	2
(Dark Green Rush) Scirpus fluviatilis	) 2	2
(River Bulrush) Scirpus validus	2	2
(Softstem Bulrush) Spartina pectinata	2	2
(Cord grass)	4	



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. 250.07	Seeding	
CLASS - TYPE	SEEDS	KG/HECTARE(LBS./ACRE)
5 Forb With Annuals Mixture	Annuals Mixture (Below) Forb Mixture (Below)	1 (1) 10 (10)
	exture not exceeding 25% by becies, of the following:	y
Chrysanthemum Gaillardia pulche Ratibida column	olata (Sand Coreopsis) n maximum (Shasta Daisy) elle (Blanket Flower) itera (Long-Headed Coneflo (Black-Eyed Susan)	ower)
	e, not exceeding 5% by ne species, of the following:	
Anemone cylind Asclepias tubero Aster azureus (S Aster laevis (Sm Aster novae-ang Baptisia leucant Ceanothus ame Coreopsis palma Echinacea pallio Eryngium yuccif Helianthus molli Heliopsis heliant Heuchera richar Liatris aspera (F Liatris pyscostad Monarda fistulos Parthenium inte Pedicularis cana Petalostemum p Physostegia virg Potentilla arguta Ratibida pinnata		Clover) Clover)
Silphium laciniat Silphium terebin Solidago rigida ( Tradescantia oh	cum (Compass Plant) thinaceum (Prairie Dock) (Rigid Goldenrod) iensis (Spiderwort) rirginicum (Culver's Root)	

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CLA	SS - TYPE	SEEDS	KG/HECTARE(LBS./ACRE)
5A	Large Flower Native Forb Mixture	Forb Mixture (Below)	5 (5)
	<u>Species</u>	<u>% B</u> y	/ Weight 5/
	Aster novae-angliae (New England Aster Echinacea pallida	)	5
	(Pale Purple Coneflo	ower)	10
	Helianthus mollis (Downy Sunflower) Heliopsis helianthoide	e	10
	(Ox-Eye)	3	10
	Liatris pyscostachya (Prairie Blazing Star Ratibida pinnata	)	10
	(Yellow Coneflower)		5
	Rudbeckia hirta (Black-Eyed Susan) Silphium laciniatum		10
	(compass Plant)		10
	Silphium terebinthinad (Prairie Dock)	eum	20
	Solidago rigida (Rigid Goldenrod)		10

# Seeding



CLA	SS - TYPE	SEEDS	KG/HECTARE(LBS./ACRE)
5B	Wetland Forb	Forb Mixture (Below)	2 (2)
	<u>Species</u>	<u>% By</u>	Weight 5/
	Acorus calamus (Sweet Flag)		3
	Angelica atropurpurea	a	
	(Angelica) Ascelepias incarnata		7
	Swamp Milkweed		2
	Aster puniceus (Purple Stemmed A	ster)	10
	Bidens cernua (Beggarticks)		7
	Eupatorium maculatur (Spotted Joe Pye W		7
	Eupatorium perfoliatu (Boneset)		7
	Hèlenium autumnale (Autumn Sneeze we	eed)	2
	Iris virginica shrevei (Blue Flag Iris)	,	2
	Lobelia cardinalis		
	(Cardinal Flower) Lobelia siphilitica		5
	(Great Blue Lobelia Lobelia siphilitica	)	2
	(Great Blue Lobelia	)	5
	Lythrum alatum (Winged Loosestrife		2
	Physostegia virginian (False Dragonhead)		5
	Polygonium cocciniun (Smartweed)	n	10
	Polygonum amphibiur (Water Smartweed)		10
	Pychanthemum virgin		
	(Mountain Mint) Rudbeckia laciniata		5
	(Cut-leaf Coneflowe	r)	5
	Solidago riddellii (Riddell Goldenrod)		2
	Sparganium eurycarp (Giant Burreed)	um	5
6	Conservation Mixture	Smooth Brome Grass Vernal Alfalfa 2/ Oats, Spring	45 (40) 15 (15) 55 (48)
6A	Salt Tolerant Conservation Mixture	Smooth Brome Grass Vernal Alfalfa 2/ Oats, Spring Fults Salt Grass 1/	45 (40) 15 (15) 55 (48) 25 (20)

CLASS - TYPE	SEEDS	KG/HECTARE(LBS./ACRE)
7 Temporary Erosion Control Mixture	Perennial Ryegrass Oats, Spring 4/	55 (50) 70 (64)

Note 1. Fults pucinnellia distans

Note 2. Legumes - inoculation required

Note 3. Specific variety as shown in the plans or approved by the Engineer.

Note 4. Other seeds may be used if approved by the Engineer.

Note 5. PLS = Pure Live Seed

Variation in the Class 4 or 5 seed quantities or varieties will be allowed in the event of a crop failure or other unforeseen conditions. The Contractor shall provide for the approval of the Engineer a written description of the changed Class 4 or 5 Mixture, the reasons for the change, and the name of the seed supplier.

## 250.08 Method of Measurement.

- (a) Contract Quantities. The requirement for use of contract quantities shall be according to Article 202.07(a).
- (b) Measured Quantities. Seeding of the class specified and mowing will be measured in hectares (acres) of surface area seeded or mowed.

The exact locations of seeding and mowing will be determined in the field by the Engineer, and the quantities will be adjusted accordingly.

Fertilizer will be measured by weight in kilograms (pounds) of actual nutrients. The following formula will be used to determine the kilograms (pounds) of fertilizer nutrients applied:

(Total kilograms (pounds) of mixed fertilizer)

Х

(Percentage of each nutrient in the fertilizer applied)

= kilograms (pounds) of each fertilizer nutrient

Agricultural Ground Limestone will be measured by weight in metric tons (tons) of Agricultural Ground Limestone having an effective neutralizing value of 67.5 (4-year base, a source correction factor of 1.0). Pay quantity will be computed according to procedures established by the Department. Applied quantity shall be the plan quantity multiplied by the source correction factor. The pay quantity shall be corrected for variations in applied quantity.

Payment will not be made for fertilizer nutrients in excess of 103 percent or agricultural ground limestone in excess of 108 percent of the amounts specified by the Engineer.

Selective mowing stakes will be measured as each in place.

Art. 250.09 Seeding

**250.09** Basis of Payment. This work will be paid for at the contract unit price per hectare (acre) for SEEDING or INTERSEEDING of the Class specified; at the contract unit price per kilogram (pound) for NITROGEN FERTILIZER NUTRIENT, PHOSPHORUS FERTILIZER NUTRIENT and POTASSIUM FERTILIZER NUTRIENT; and at the contract unit price per metric ton (ton) for AGRICULTURAL GROUND LIMESTONE.

Mowing will be paid for at the contract unit price per hectare (acre) for MOWING. Only the initial mowing will be paid for. Any subsequent mowing required to obtain a height of not more than 75 mm (3 inches) or to disperse mowed material will be considered as included in the cost of the initial mowing.

Selective Mowing Stakes will be paid for at the contract unit price each for SELECTIVE MOWING STAKES. Furnishing innoculant shall be included in the contract unit price per hectare (acre) for Seeding of the class specified.

## **SECTION 251. MULCH**

- **251.01 Description.** This item shall consist of furnishing, transporting, and placing mulch or erosion control blanket over seeded areas.
- **251.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 Materials:

	Item	Article/Section
(a)	Bituminous Materials	1009.01 - 1009.04, 1009.07
(b)	Mulch Material	1081.06(a)
(c)	Excelsior Blanket	1081.10(a)
(d)	Knitted Straw Mat	1081.10(b)
(e)	Staples	1081.10(c)

### CONSTRUCTION REQUIREMENTS

- **251.03 Mulching Seeded Areas.** Within 24 hours from the time seeding has been performed, the seeded area shall be given a covering of mulch by one of the following methods as designated on the plans. On slopes steeper than 1:3(V:H), mulch shall be applied the same day as seeded. Mulch shall be applied uniformly at the rate specified.
  - (a) Method 1. This method shall consist of hand or machine application of straw mulch at the rate of 4.5 metric tons/ha (2 tons per acre). The mulch shall be loose enough to permit air to circulate but compact enough to reduce erosion. If baled mulch material is used, care shall be taken that the material is in a loosened condition and contains no lumps or knots of compacted material.
  - (b) Method 2. Method 2 shall consist of placing and stabilizing straw at the rate of 4.5 metric tons/ha (2 tons per acre) over seeded areas. All requirements of Method 1 must be met plus the mulch shall be thoroughly stabilized. The Contractor has the option of any of the following procedures for stabilizing the straw:
    - (1) Procedure 1 shall consist of partially coating the mulch with emulsified

asphalt.

The coated straw shall be placed by equipment which will blow or eject, by means of constant air stream, controlled quantities of the straw and emulsified asphalt in a uniform pattern over the specified area. If the straw is excessively cut or broken, the Contractor shall take measures to reduce the cutting or breakage to a limit approved by the Engineer.

The emulsified asphalt shall be introduced into the air stream of the machine by means of a spray that will partially coat the straw with a spotty asphalt tack. The rate of application of emulsified asphalt shall be 300 L per metric ton (75 gals. per ton) of straw.

- (2) Procedure 2 shall consist of anchoring the straw into the soil by means of a mechanical stabilizer with dull blades or disks. These blades or disks shall be without camber, approximately 500 mm (20 inches) in diameter, notched spaced at approximately 200 mm (8-inch) intervals and equipped with scrapers. The stabilizer shall measure approximately 450 kg (1000 lbs.), have a working width not exceeding 1.8 m (72 inches) and shall be equipped with a ballast compartment, so that when directed, mass (weight) can be increased.
- (3) Procedure 3 shall consist of stabilizing the straw with an approved mulch blower followed immediately by an overspray application of hydraulic mulch. The hydraulic mulch shall be applied as a slurry of 850 kg (750 lbs.) of mulch and 9500 L (1000 gals.) of water per hectare (acre) by an approved hydraulic mulch applicator. The hydraulic mulch slurry shall be agitated a minimum of 5 minutes before application and shall be agitated during application.
- (4) Procedure 4 shall consist of stabilizing the straw mulch using an approved mulch blower with chemical mulch binder simultaneously with the straw as in Procedure 1, above, or with chemical mulch binder applied as an overspray according to Procedure 3. The chemical mulch binder shall be approved by the Engineer and shall be applied at the rate and in the manner recommended by the supplier and approved by the Engineer.
- (c) Method 3. This method shall not be used on slopes steeper than 1:3(V:H). This method shall consist of machine application of wood or paper fiber hydraulic mulch at the specified rate using an approved hydraulic seeder. The hydraulic mulch shall be applied as a slurry of 2300 kg (2000 lbs.) of mulch and not less than 19000 L (2000 gals.) of water per hectare (acre). The hydraulic mulch slurry shall be agitated a minimum of 5 minutes before application. The seeding shall not be applied concurrently with this operation.

Following the mulching operation, foot and vehicular traffic, or the movement of equipment over the mulched area shall be prohibited. At any location where mulching has been displaced by any Contractor's equipment or personnel, the seeding and mulch or other work damaged as a result of that displacement shall be repaired or replaced immediately at the Contractor's expense, in a manner satisfactory to the Engineer.

Art. 251.04 Mulch

**251.04 Erosion Control Blanket.** At the option of the Contractor, erosion control blanket may be placed using either excelsior blanket or knitted straw mat. The blanket shall be placed within 24 hours after seeding operations have been completed on the areas specified. Prior to placing the blanket, the areas to be covered shall be relatively free of all rocks or clods over 40 mm (1 1/2 inch) in diameter, and all sticks or other foreign material which will prevent the close contact of the blanket with the seed bed. If, as a result of rain, the prepared seed bed becomes crusted or eroded, or if eroded places, ruts or depressions exist for any reason, the Contractor will be required to rework the soil until it is smooth and to reseed such areas which are reworked. After the area has been properly shaped, fertilized and seeded, the blanket shall be laid out flat, evenly and smoothly, without stretching the material.

The blankets shall be placed so that the netting is on the top and the fibers are in contact with the soil. Placing and anchoring the blankets in ditches and on slopes shall be as follows:

(a) Excelsior Blanket. For placement in ditches, the blankets shall be applied in the direction of the flow of the water and butted snugly against each other. The blankets shall be stapled in place, using 4 staples across the upstream end at the start of each roll and placing staples on 1.2-m (4-ft.) centers along each side. A common row of staples shall be used along seams of adjoining blankets. All seams shall overlap at least 50 mm (2 inches).

On slopes, the blankets shall be applied either horizontally or vertically to the contour and stapled in place similar to ditch applications except that the space interval shall be 1.8 m (6 ft.).

(b) Knitted Straw Mat. The rolls shall be butted snugly together and stapled in place. The staples shall be driven through the blanket vertically into the ground for the full length. Each staple shall anchor the plastic mesh. The staples shall be spaced in a diamond pattern with the longer dimension in the direction of the slope and the shorter dimension across the slope. The longer dimension shall be a maximum of 1.8 m (6 ft.) and the shorter dimension shall be a maximum of 900 mm (3 ft.). A common row of staples may be used on adjoining rolls.

For placement on slopes, knitted straw mat shall be unrolled in the direction of the slope and shall extend a minimum of 900 mm (3 ft.) over the crest of the slope. On slope applications, 6 staples shall be installed on uniform spacing across the uphill end of each roll. The downhill ends of the lowermost rolls across the slope also shall be anchored with 6 staples, placed on uniform spacing.

For placement in ditch lines, the erosion control blanket shall be unrolled parallel to the centerline of the ditch so that there are no longitudinal seams within 600 mm (24 inches) of the bottom centerline of the ditch. In ditch lines, 6 staples shall be installed at uniform spacing across the upstream end of each roll.

#### 251.05 Method of Measurement.

(a) Contract Quantities. The requirement for use of contract quantities shall

be according to Article 202.07(a).



- (b) Measured Quantities. Mulch Methods 1, 2, and 3 will be measured for payment in metric tons (tons) of surface area mulched. Erosion Control Blanket will be measured for payment in place in square meters (square yards) of actual surface area covered.
- **251.06 Basis of Payment.** This work will be paid for at the contract unit price per metric tons (ton) for MULCH, METHOD 1; MULCH, METHOD 2; or MULCH, METHOD 3; and at the contract unit price per square meter (square yard) for EROSION CONTROL BLANKET.

### **SECTION 252. SODDING**

- **252.01 Description.** This work shall consist of preparing the ground surface and furnishing, transporting and placing sod and other materials required in the sodding operations.
- **252.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 Materials:

	Item Ar	ticle/Section
(a)	Sod	1081.03
	Salt Tolerant Sod	
	Agricultural Ground Limestone	
(d)	Fertilizer	1081.08

### **CONSTRUCTION REQUIREMENTS**

**252.03 Ground Preparation.** The area to be sodded shall be finished according to Section 212 before sodding operations are begun. Immediately prior, but not in excess of 24 hours before the sod is placed, the soil surface shall be worked until it is relatively free from debris, washes, gullies, clods and stones. The surface shall be worked to a depth of not less than 75 mm (3 inches) with a disk, tiller or other equipment approved by the Engineer. Prepared surfaces that become crusted shall be reworked to an acceptable condition for sodding.

All soil surfaces shall be moist when the sod is placed. When directed by the Engineer, the Contractor shall be required to apply water to dry soil surfaces at a minimum rate of  $5 \text{ L/m}^2$  (1 gal. per sq. yd.) immediately prior to placing the sod.

When specified, agricultural ground limestone and fertilizer nutrients shall be applied at the designated rates over the areas to be sodded.



When fertilizer is specified, 200 kg (180 lbs.) of fertilizer nutrients per hectare (acre) shall be applied over the areas to be sodded at a 5:3:2 ratio as follows:

Nitrogen Fertilizer Nutrients

100 kg/ha (90 lbs./acre)

Phosphorus Fertilizer Nutrients

60 kg/ha (54 lbs./acre)

Potassium Fertilizer Nutrients

40 kg/ha (36 lbs./acre)

**252.04 Sodding Time.** Sod shall be placed when the ground is in a workable condition and temperatures are less than 26 °C (80 °F.). Sod shall not be placed

when the sod or ground surface is frozen or during an extended drought.

**252.05 Transportation.** All sod shall be properly protected during transportation to maintain it in a live, healthy condition.

Sod cut for more than 48 hours shall only be used with the approval of the Engineer. Any sod that has dried out, has heated to over 38 °C (100 °F.), or is frozen prior to placing will be rejected and shall be immediately removed from the jobsite by the Contractor.

**252.06 Placing Sod.** The sod shall be placed on the prepared surface with the edges in close contact and alternate courses staggered.

In ditches, the sod shall be placed with the longer dimension perpendicular to the flow of water in the ditch. On slopes, starting at the bottom of the slope, the sod shall be placed with the longer dimension parallel to the contours of the ground. The exposed edges of sod shall be buried flush with the adjacent soil.

On slopes where the sod may be displaced during sodding operations, the workmen shall work from ladders or treaded planks.

- **252.07 Staking Sod.** The sod shall be staked on all slopes of 1:2(V:H) or steeper. Sod shall be staked with not less than 4 stakes per square meter (square yard) with at least one stake for each piece of sod. Stakes shall be a minimum of 150 mm (6 inches) long. Stakes shall be installed so that they hold the sod firmly in place yet present no danger to pedestrians or mowing crews. The type of stake and the method of installation shall meet the approval of the Engineer.
- **252.08 Sod Watering.** Within 2 hours after the sod has been placed, 25 L of water per m<sup>2</sup> (5 gals. of water per sq. yd.) shall be applied. Thereafter, on days designated by the Engineer, additional water shall be applied at the rate of 15 L of water per m<sup>2</sup> (3 gals. per sq. yd.). The number of additional applications shall not exceed 7 during the period of establishment, defined as the period of time between sod placement and when the sod becomes knitted to the soil and is growing in place.

The Contractor shall have on hand enough equipment to completely water all sodded areas in 2 days at watering rates specified during the period of establishment. The Engineer will make periodic checks of the Contractor's watering equipment to determine its adequacy and operating condition.

All watering described shall be done with a spray application. An open end hose will not be acceptable. The method of watering shall meet the approval of the Engineer.

- **252.09** Supplemental Watering. During periods of intense heat or subnormal rainfall, supplemental watering may be required after the initial and 7 additional waterings and prior to acceptance of the work. Supplemental watering shall be performed when directed by the Engineer. Water shall be applied at the rate specified by the Engineer within 24 hours of notice. Supplemental watering may be performed during the period of establishment or any time prior to final acceptance of the project.
- **252.10 Disposal of Surplus Material.** Surplus and waste materials resulting from sodding operations shall be disposed of by the Contractor, at his/her own expense, according to Article 202.03.

Sodding Art. 252.11

**252.11 Inspection.** The Contractor shall notify the Engineer of the localities from which the sod is to be obtained so that an authorized representative may inspect the fields for approval.

A copy of the inspection certificate required by law to this effect shall accompany each shipment and on arrival shall be filed with the Engineer.

With every shipment of Salt Tolerant Sod, the Contractor shall provide to the Engineer a letter of certification from an authorized representative of the nursery stating that the seed mixture used in the sod conforms to the specifications.

**252.12 Method of Measurement.** Sodding will be measured for payment in place and the area computed in square meters (square yards). To be acceptable, the sod shall be in a live, healthy condition and be knitted to the soil. When directed by the Engineer, any defective or unacceptable sod shall be removed, replaced and watered by the Contractor at his/her own expense and according to the requirements specified. Only acceptable sod will be measured for payment.

Sod watering will not be measured for payment.

Supplemental watering will be measured for payment in units of 1000 L (1000 gals.) of water applied on the sodded areas.

Fertilizer will be measured for payment according to Article 250.08.

Agricultural Ground Limestone will be measured for payment according to Article 250.08.

**252.13 Basis of Payment.** Sodding will be paid for at the contract unit price per square meter (square yard) for SODDING or SODDING, SALT TOLERANT, which price shall include furnishing and placing the sod, including sod watering.

Supplemental watering will be paid for at the contract unit price per unit for SUPPLEMENTAL WATERING.

Fertilizer and Agricultural Ground Limestone will be paid for according to Article 250.09.

# **SECTION 253. PLANTING WOODY PLANTS**

- **253.01 Description.** This work shall consist of furnishing, transporting, and planting woody plants such as trees, shrubs, vines, and seedlings. The work shall also include all mulching, bracing, wrapping, watering, weeding, replacement of plants when required, and all work described.
- **253.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 Materials:

	Item	Article/Section
(a)	Item Trees, Shrubs, Vines and Seedlings	1081.01
(b)	Topsoil	1081.05
(c)	Mulch Material	1081.06(b)
(d)	Bracing	1081.11
(e)	Weed Barrier Fabric	1081.12

## CONSTRUCTION REQUIREMENTS

**253.03 Planting Time.** Except for container grown items, plants must be dormant when delivered to the storage site or project.

In reference to the following planting dates, that portion of the State which lies north of a line formed by the southern boundaries of Hancock, Schuyler, Mason, Tazewell, McLean, Ford, and Iroquois Counties shall be considered the northern zone, while that portion of the State which lies south of this line shall be considered the southern zone.

Bare root plant material shall be planted only when the air temperatures exceed 2 °C (35 °F.).

- (a) Spring Planting. This work shall be performed from the time the soil can be worked until the plant, under field conditions, is not dormant except that:
  - (1) Evergreen planting shall end April 1 in the southern zone and April 30 in the northern zone.
  - (2) Seedlings, broadleaf evergreens, vines and willow (Salix spp.), poplar (Populus spp.), oak (Quercus spp.), alder (Alnus spp.), birch (Betula spp.), hawthorn (Crataegus spp.), red maple (Acer Rubrum), cherry (Prunus spp.), and pear (Pyrus spp.) species shall be planted only during the spring planting season.
  - (3) The planting time may be extended for container grown plants if the Engineer determines that the weather conditions are favorable.
- (b) Fall Planting. This work shall be performed from the time the plant becomes dormant until the ground cannot be satisfactorily worked except that evergreen planting shall be performed between August 15 and October 15 in the northern zone and between September 1 and November 1 in the southern zone.

All plant material not planted according to the specified seasonal date shall require prior written approval from the Engineer. Failure to secure such approval shall result in the rejection of the plant material and replacement by the Contractor at his/her expense.

- **253.04 Digging of Plants.** Plants shall not be dug until the Contractor is ready to transport them from their original locations to the site of the work or approved storage. The maximum time lapse between digging and being properly loaded, as defined in Article 1081.01 for delivery to the site of the work or being placed in approved storage, shall be 4 days for balled or burlapped plants and one day for bare root plants. They shall be dug with care, avoiding injury to the plants or loss or damage of the roots, particular attention being given to fibrous roots. Immediately after digging, roots shall be protected against drying out and freezing. Bare root plants shall be dug only when air temperatures exceed 2 °C (35 °F.).
- **253.05 Transportation.** During transportation, the Contractor shall exercise care to prevent injury and drying out of the plants. Upon arrival at the temporary storage location or the site of the work, plants will be inspected for proper shipping procedures as defined in Article 1081.01(d). Should the roots be dried out, large branches be broken, balls of earth be broken or loosened, or areas of bark be torn,

the Engineer may reject the injured tree. When a tree has been so rejected, the Contractor shall at once remove it from the area of the work and replace it.

- **253.06 Temporary Storage.** No plant shall remain in temporary storage over the summer. Plants delivered to the project that are not to be planted immediately shall be protected in the following manner:
  - (a) Bare Root Plants. Plants may remain on the site of the work only 24 hours prior to being planted or placed in storage. During this 24 hour period, the Contractor shall continue to exercise care to prevent injury and drying out of the plants. The roots of plants to be placed in storage shall first be puddled in a paste solution of topsoil and water. The plants shall then be protected and kept moist by "heeling-in" the roots or by placing the plant in a cool moist storage building. The "heeling-in" procedure shall require the plants to be separated and the roots heeled in a suitable moist soil. If plants are stored in a building, the roots shall be covered with a suitable moist mulch. Winter storage of bare rooted plants will be allowed only in temperature and humidity controlled buildings. The Engineer shall approve the storage methods. The duration of storage, the method of storage and the materials used for mulch and "heeling-in" shall meet with the approval of the Engineer.
  - (b) Balled and Burlapped Plants and Container Grown Plants. Plants may remain on the site of the work only 72 hours prior to being planted or placed in storage.

Balled and burlapped plants shall be kept moist and their solidity carefully preserved. To prevent drying out or freezing, they shall be stored either in a cool moist storage building or placed in a compact group with a suitable mulch material placed around and between the balls so they are completely covered.

Container grown plant material shall be kept moist by watering as directed by the Engineer. To prevent freezing, they shall be stored either in a cool moist storage building or placed in a compact group with a suitable mulch material placed around and between the containers so that they are completely covered.

The duration of storage, method of storage and mulch material for balled and burlap material and container grown plant material shall meet the approval of the Engineer.

- **253.07 Layout of Planting.** The area to be planted shall be finished to line and grade before planting operations are begun. The Contractor shall furnish all marking flags for locating plants and shall mark the common name of plants. The Engineer will place the marking flags and outline each area for mass or solid planting. Where seedlings are to be planted the planting areas shall be delineated with selective mowing stakes. Selective mowing stakes shall be steel posts as described in Article 1081.11 The selective mowing stakes shall be driven to a height of 900 mm (3 ft.).
- **253.08** Excavation of Plant Holes. The sides of all plant holes shall be vertical and the bottoms horizontal. On slopes, the depth of excavation will be measured at

the center of the hole. The excess material excavated from the holes shall be spread in the immediate area as directed by the Engineer. The excavated material shall not be stockpiled on turf or in ditches. The sides of holes shall not be glazed or smooth.

(a) Excavation for Trees. Holes for trees shall be dug at the location indicated by the marking flags. The diameter and depth of the hole shall be according to the following chart:

TREE SIZE	MINIMUM DIAMETER OF HOLE	DEPTH OF HOLE
1.2 m (4') < 2.4 m (8 ft.) (height)  2.4 m (8 ft.) < 3.6 m (12') (height) 25 mm (1") < 50 mm (2") (diameter) 50 mm (2") < 75 mm (3") (diameter) 75 mm (3") < 100 mm (4") (diameter) 100 mm (4") < 125 mm (5") (diameter) 125 mm (5") or larger (diameter)	750 mm (30") 900 mm (36") 900 mm (36") 1.2 m (48") 1.5 m (60") 1.8 m (72") Ball diameter + 900 mm (36")	Ball depth - 50 mm (2") " " " "

(b) Excavation for Shrubs, Vines, and Seedlings. Holes for shrubs, vines, and seedlings shall be dug within the marked outline of the planting bed. The spacing of planting will be designated on the plans. Spacing shall be measured from center-to-center and alternate rows shall be staggered.

Prior to digging shrub and vine holes, existing vegetation on the area shall be mowed or treated with a non-selective, post emergent non-residual herbicide approved by the Engineer. The area shall then be tilled to a minimum depth of 50 mm (2 inches) until free of debris, gullies, clods, weeds, stones, and roots.

Holes for shrubs shall be dug to a minimum diameter and depth of 450 mm (18 inches). Holes for vines shall be dug to a minimum diameter and depth of 200 mm (8 inches).

Immediately prior to planting seedlings, the existing grass and weed growth within the planting area shall be cut to a maximum height of 50 mm (2 inches). On slopes flatter than 1:3(V:H), the soil adjacent to the plant row parallel to the contour shall be prepared by cultivating or scalping to remove all grass and weed growth, in a continuous strip not less than 450 mm (18 inches) wide. The seedlings shall be planted in the center of this strip.

Holes for seedlings shall be made large enough to accommodate the root system with a spade, planting bar or an approved mechanical tree planting machine.

Individual holes for container grown plants shall be excavated to the same dimensions for comparable size balled and burlapped material.

**253.09 Pruning.** All pruning shall be performed by a professional arborist. Pruning shall be done in the presence of the Engineer and in such a manner as to preserve the natural growth habit of each plant. All pruning shall be done in conformance with National Arborists Association Pruning Standards for Shade Trees Class 1 - Fine Pruning.

The ends of all broken and damaged roots of 6 mm (1/4 inch) or larger shall be pruned with a clean cut, removing only the injured portion. All broken branches, stubs and improper cuts of former pruning shall be removed.

- (a) Deciduous Trees. Pruning shall consist of thinning the twigs or branches as dictated by the habit of growth of the various types of the trees to be pruned, and as directed by the Engineer. The leader and terminal buds shall not be cut unless directed by the Engineer.
- (b) Deciduous Shrubs. In general, shrubs shall be cut back to 1/2 of their height. Shrubs that are slow growing or do not sucker readily shall be pruned in the same manner as deciduous shade trees.
- (c) Evergreens. Evergreens shall not be pruned except to remove broken or dead branches.
- **253.10 Planting Procedures.** When directed by the Engineer, the backfill shall consist of the soil removed from the hole and topsoil as needed to match the level of the existing grade. If the existing soil is determined to be unsuitable, the backfill shall consist of topsoil as approved by the Engineer. Topsoil shall be stockpiled only at locations approved by the Engineer.

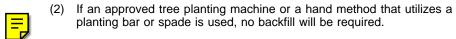
The backfill soil shall, at the time of planting, be in a loose, friable condition. At no time shall the backfill or other topsoil used on the job be stockpiled on turf or in ditches.

All plants shall be placed in a plumb position and set 50 mm (2 inches) higher than the depth they grew in the nursery. Prepared backfill shall be placed around the root system. Tamping or watering shall accompany the backfilling operation to eliminate air pockets.

Thorough watering of trees, shrubs, and vines, with a method approved by the Engineer, shall follow the backfilling operation. This watering shall completely saturate the backfill and be performed during the same day of planting. After the ground settles, as a result of the watering, additional backfill shall be placed to match the level of the finished grade. Approved watering equipment shall be at the site of the work and in operational condition prior to starting the planting operation.

- (a) Balled and Burlapped Plants. After the plant is placed in the hole, all cords and burlap shall be cut away from the trunk.
- (b) Container Grown Plants. Prior to placing the plant in the hole, the container shall be removed with care so as not to disturb the ball of soil that contains the root system. During the planting operation, care shall be taken not to destroy the solidity of the ball of soil. Pots of material that will decompose in one growing season need not be removed.

- (c) Bare Root Plants. The roots shall be carefully spread in a natural position and prepared backfill shall be worked in around the roots so each root is individually packed to eliminate air pockets. The plant shall be gently raised and lowered to assure contact of the roots with the soil.
- (d) Seedling Plants. When seedlings are removed from storage for planting, they shall be transported to the planting site in containers of water and the roots shall be continuously immersed until planted. Any unplanted seedlings left at the end of each day shall be removed from the water, the roots wrapped in moist materials and the seedlings placed in storage.
  - (1) If holes are prepared according to Article 253.08, the roots shall be placed in the center of the hole and the backfill shall be compacted around the roots to eliminate air pockets. The backfill shall be saturated with water after the plant is placed.



**253.11 Mulch Cover.** Within 30 days after planting, weed barrier fabric shall be placed around all plants and covered with mulch in the entire mulched bed or saucer area specified.

The fabric shall be cut as needed and fitted around the plant material. Wire staples, meeting the approval of the Engineer and driven at a 90 degree angle to the plane of the soil, shall be installed to hold the fabric in place. A minimum of one staple per square meter (square yard) is required. Strips of fabric shall overlap 150 mm (6 inches) at the seams. After placing the weed barrier fabric, the top surface. of the fabric shall be clear of any topsoil and mulch shall be placed in such a way as to completely cover the weed barrier to a depth of 100 mm (4 inches).

- **253.12 Wrapping.** Within 7 days after planting, a double layer of commercial screen wire mesh shall be wrapped around the trunk of all deciduous trees. All other plants planted individually shall be similarly wrapped when directed by the Engineer. The screen wire shall be secured to itself with staples or single wire strand tied to the mesh. The lower edge of the screen wire shall be in continuous contact with the ground and shall extend up to the lowest major branch.
- **253.13 Bracing.** All deciduous and evergreen trees over 2.5 m (8 ft.) in height shall require three 2.5 m (8 ft.) long steel posts so placed that they are equidistant from each other and adjacent to the outside of the ball. The posts shall be driven vertically to a depth of 450 mm (18 inches) below the bottom of the hole. The anchor plate shall be aligned perpendicular to a line between the tree and the post. The tree shall be firmly attached to each post with a double guy of 2.03 mm (14-gage) steel wire. The portion of the wire in contact with the tree shall be encased in a hose of a type and length approved by the Engineer.

During the life of the contract, if trees blow down, or are otherwise injured because of improper bracing, the Engineer may reject such injured trees, and the rejected trees shall be replaced by the Contractor at his/her own expense.

**253.14 Period of Establishment.** Partial inspections of planting work as specified in Article 105.13, will not be made unless the planting work is unavoidably detained due to uncompleted highway construction that must precede the planting

operation. Inspection for the successful completion of the period of establishment will be made during the month of September each year. To qualify for inspection, the Contractor must receive written certification from the Engineer stating that all specified plant material was in place and in a live healthy condition on or before June 1 of the year of inspection. To be acceptable, the plant must be in a live healthy condition, representative of its species. No portion of this work will be inspected until all items of work are completed.

This delay in inspection and acceptance of plant material shall not delay acceptance of the entire project and final payment due if the Contractor provides the Department with a surety bond in the full amount of all plant material items listed in the contract. The bond shall be executed prior to acceptance and final payment of the non-plant material items and shall be in full force and effect until final inspection and acceptance of the plant material.

The Department will assume the responsibility for all plant material found to be satisfactory at the time of inspection for successful completion of the period of establishment. Plants that do not meet the requirements for acceptance shall be replaced by the Contractor at his/her own expense following the date of inspection and prior to November 30. Items specified for spring planting only shall be planted prior to the following April 30. Changes in the above dates will be allowed by the Engineer only if extreme weather conditions or other mitigating circumstances so dictate. When replacements are completed, the Contractor shall weed and thoroughly clean up the entire job to the satisfaction of the Engineer. Cleanup shall include pruning dead branches off the accepted plant material, spraying insect infected plants, removing staking and screening material, weeding, restoring mulch, removing work-related debris and generally cleaning up the work site. operations have been completed, inspection will be made for replacement items only. All replacement items shall meet and be planted according to the original job specifications. Replacement plantings need not undergo a period of establishment to be accepted. However, replacement plants must be properly installed and in a live healthy condition at the time of inspection. Should replacements include both spring and fall items, the Contractor may elect to plant all replacements in the spring, prior to May 15.

The Contractor shall remove immediately from the site of the work any dead plant material. During spring or fall planting, the Contractor will not be permitted to terminate the operation until all plant material is in a live, healthy condition. All plant material which dies within 15 days after being planted shall be replaced at that time and shall be considered as part of the original planting and be subject to the requirements of the period of establishment.

- **253.15 Plant Care.** During the period of establishment, the Contractor shall properly care for all plants including weeding, watering, adjusting of braces, repair of water saucers or other work which is necessary to maintain the health and satisfactory appearance of the plantings. All requirements for proper care during the period of establishment shall be considered as included in the cost of the contract and shall be performed within 5 days following notification by the Engineer.
  - (a) During the period of establishment, additional watering shall be performed at least once within every 30 days during the months of May through December. The Engineer may direct the Contractor to adjust the watering rate and frequency depending upon weather conditions.

The water shall be applied to individual plants in such a manner that the plant hole shall be saturated without allowing the water to overflow beyond the earthen saucer. Watering of plants in beds shall be applied in such a manner that all plant holes are uniformly saturated without allowing the water to flow beyond the periphery of the bed. The plants to be watered and the method of application will be approved by the Engineer. The Contractor will not be relieved in any way from the responsibility for unsatisfactory plants due to the amount of watering.

(b) During the period of establishment, weeds and grass growth shall be removed from within the earthen saucer of individual trees and from the area within the mulched plant beds. This weeding shall be performed twice during each of the months of May through September. The Contractor will not be relieved in any way from the responsibility for unsatisfactory plants due to the extent of weeding.

The weeding may be performed in any manner approved by the Engineer provided the weed and grass growth, including their roots and stems, are removed from the area specified. Mulch disturbed by the weeding operation shall be replaced to its original condition. All debris which results from this operation must be removed from the right of way at the end of each day.



**253.16 Method of Measurement.** Trees, shrubs, and vines will be measured for payment in place as individual plants. Seedlings will be measured for payment in units of 1000 plants in place. Only acceptable plants will be measured for payment.

**253.17 Basis of Payment.** This work will be paid for at the contract unit price each for several kinds and sizes of TREES, SHRUBS, and VINES, and per unit for SEEDLINGS.

#### **SECTION 254. PLANTING PERENNIAL PLANTS**

**254.01 Description.** This work shall consist of furnishing, transporting, and planting perennial plants.

**254.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 - Materials:

	Item	Article/Section
(a)	Bulbs and Tubers	1081.02
(b)	Herbaceous Plants	1081.02
(c)	Mulch Material	1081.06(b)

# 254.03 Types and Mixtures.

- (a) Bulbs. Bulbs shall be of the color and variety specified.
- (b) Ornamental Herbacious Plants. Ornamental herbacious plants shall be of the color and variety specified. Bare root plants may be used if installed in the spring prior to the normal budding time of the plant. Potted plants shall be used when specified on the plans or directed by the Engineer.

(c) Prairie Type Plants. When specified, prairie type plants shall be installed according to the varieties shown on the plans. When no varieties are specified, the following mixture shall be used:

Prairie Type. A random mixture consisting of no more than 20% of any one of the species.

Aster laevis - Smooth Aster
Baptisia leucantha - White Wild Indigo
Echinacea pallida - Pale Purple Coneflower
Eryngium yuccifolium - Rattlesnake Master
Liatris pyscostachya - Gayfeather
Monarda fistulosa - Wild Bergamont
Ratibida pinnata - Yellow Coneflower
Rudbeckia hirta - Black-eyed Susan
Silphium terebinthinaceum - Prairie Dock
Tradescantia ohiensis - Spiderwort

(d) Wetland Type Plants. When specified, wetland emergent plants or sedge meadow plants shall be installed according to the varieties shown on the plans. When no varieties are specified, the following mixtures shall be used:

Wetland Emergent Type. An equal number of each of the following species:

# 0 to 150 mm (0 to 6 Inch) Water Depth Plants

Acorus calamus - Sweet Flag Iris virginica shrevei - Blue Flag Iris Polygonum coccineum - Marsh Smartweed Sagittaria latifolia - Arrowhead Sparganium eurycarpum - Large Fruited Burreed

## 150 to 300 mm (6 to 12 Inch) Water Depth Plants

Nuphar advena - Yellow (Spatterdock) Water-lily Nymphaea tuberosa - White (Tuberous) Water-lily Pontederia cordata - Pickerelweed Sagittarium rigida - Sessile-fruited Arrowhead Scirpus acutus - Hardstem Bulrush

Sedge Meadow Type. A random mixture consisting of no more than 20% of any one of the species.

Calamagrostis canadensis - Blue Joint Grass Carex lacustris - Lake Bank Sedge Carex hystricina - Bottle Brush Sedge Carex stricta - Tussock Sedge Juncus tenuis - Path Rush Scirpus fluviatilis - River Bulrush Spartina pectinata - Prairie Cord Grass

(e) Woodland Type Plants. When specified, woodland plants shall be planted

according to the varieties shown on the plans. When no varieties are specified, the following mixture shall be used:

Woodland Type. A random mixture consisting of no more than 20% of any one of the species.

Aquilegia canadensis - Columbine
Arisaema triphyllum - Jack-In-The-Pulpit
Delphinium tricorne - Wild Larkspur
Dicentra cucullaria - Dutchman's Breeches
Dodecatheon meadia - Shooting Stars
Geranium maculatum - Wild Geranium
Hydrophyllum virginianum - Virginia Waterleaf
Mertensia virginica - Bluebells
Phlox divaricata - Blue Phlox
Polemonium reptans - Jacob's Ladder
Sangiunaria canadensis - Bloodroot
Smilacina racemosa - False Solomon's Seal
Tradescantia ohiensis - Spiderwort
Uvularia grandflora - Yellow Bellwort

- **254.04** Planting Time. Planting times for the various types of perennial plants shall be as follows:
  - (a) Bulbs. Bulbs shall be planted between October 15 and November 15.
  - (b) Ornamental Herbacious Plants, Prairie Type Plants, Wetland Emergent Type Plants, and Sedge Meadow Type Plants shall be planted between May 1 and June 15 or between August 15 and September 15.
  - (c) Woodland Type Plants shall be planted between April 1 and May 15.
- **254.05** Transporting and Storing Plants. The Engineer will inspect the plants and bulbs at the work site at the beginning of each planting day and reject any material that is not properly packaged (including clear labeling by species) or that is not in a firm, moist, or viable condition. Any plants remaining at the end of the day shall be removed from the work site and properly stored by the Contractor.

Before planting, sufficient water shall be added to potted plants to insure that the soil around the roots is not dry and crumbly when the plants are removed from the pots.

- **254.06 Layout of Planting.** When plants are specified to be planted in prepared soil planting beds, the planting bed shall be approved by the Engineer prior to planting. If no prepared soil planting bed is specified, the plants shall be planted in areas that have existing cover or have been seeded and mulched or sodded. Where perennial plants, except bulbs, shall be planted, the planting beds shall be delineated with selective mowing stakes. Selective mowing stakes shall be steel posts as described in Article 1081.11. The selective mowing stakes shall be driven into the ground to a height of 1 m (3 1/2 ft.) above the ground at locations shown on the plans and as directed by the Engineer.
- **254.07 Planting Procedures.** The spacing of the plants shall be as shown on the plans or as directed by the Engineer, to uniformly fill the planting beds.

Individual plants within the beds shall be planted as follows:

- (a) Bulbs. Bulbs shall be planted to a depth of 150 mm (6 inches) in turf areas or prepared beds.
- (b) Ornamental Herbacious Plants, Prairie Type Plants, Sedge Meadow Type Plants and Woodland Type Plants. When planted in prepared soil planting beds, these plants shall be planted by a hand method approved by the Engineer.

When planted in existing turf, the planting area shall be mowed to a maximum height of 50 mm (2 inches).

In existing cover or seeded and mulched or sodded planting areas, a 300-mm (12-inch) diameter planting area for individual plants shall be prepared. The existing cover or seed and mulch shall be cut and removed from the 300-mm (12-inch) diameter planting area and the soil within the planting area loosened to a depth of 150 mm (6 inches). The plants shall be planted within the planting area and immediately watered with at least 5 L (1 gal.) of water per plant.

**254.08 Mulching.** Within 24 hours, the plants shall be mulched with 50 mm (2 inches) of a fine grade mulch meeting the approval of the Engineer. Care shall be taken to place the mulch in a way that does not smother the plants. When plants are planted in prepared soil planting beds, the entire bed shall be mulched. Bulbs planted in existing turf need not be mulched.

#### 254.09 Period of Establishment.

- (a) No period of establishment will be required for bulbs.
- (b) Perennial plants must undergo a 30-day period of establishment. Additional waterings shall be performed at least once within every 7 days for 4 weeks following installation. Water shall be applied at the rate of 9 L/m² (2 gals. per sq. yd.). Should excess moisture prevail, the Engineer may delete any or all of the additional watering cycles. In severe weather, the Engineer may require additional waterings.

Watering of plants in beds shall be applied in such a manner that all plant holes are uniformly saturated without allowing the water to flow beyond the periphery of the bed.

At the end of the period of establishment, the Contractor will be permitted to replace any unacceptable plants.

**254.10 Method of Measurement.** This work will be measured for payment in units of 100 perennial plants of the type specified. Measurement for payment of this work will not be performed until at the end of the 30-day establishment period for the replacement planting. Only plants that are in place and alive at the time of measurement will be measured for payment except that if fewer than 25% of the plants are acceptable, a quantity equal to 25% of the number of units of plants originally planted will be considered measured for payment.

Selective mowing stakes will be measured as each in place.

**254.11** Basis of Payment. This work will be paid for at the contract unit price per unit for PERENNIAL PLANTS, of the type specified, which price shall include all materials, equipment and labor necessary to complete the work except Selective Mowing Stakes.

Selective mowing stakes will be paid for at the contract unit price each for SELECTIVE MOWING STAKES.

## **EROSION CONTROL**



#### SECTION 280. TEMPORARY EROSION CONTROL

**280.01 Description.** This work shall consist of constructing temporary erosion control systems as shown on the plans, or as directed by the Engineer during the life of the contract, to control erosion and sediment damage to the roadway, adjacent properties and water resources through the use of basins, ditch checks, temporary ditches, mulch barriers, mulches, grasses, silt filter fences, and other erosion control devices or methods.

Any temporary erosion control systems ordered by the Engineer shall be coordinated with the permanent erosion control features specified elsewhere in the contract to the extent practical to assure economical, effective and continuous erosion control throughout the construction and post construction period.

**280.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 - Materials:

	Item	Article/Section
(a)	Bale Stakes	1081.13(a)
(b)	Fence Stakes	1081.13(b)
	Hay or Straw Bales	
	Fence	
(e)	Aggregate	1081.13(e)
	Silt Filter Fence	
	Temporary Mulch Material	
	Temporary Grass Seed	



# **CONSTRUCTION REQUIREMENTS**

**280.03 General.** The Contractor and the Department shall schedule and conduct a jobsite inspection to review and designate the locations and types of erosion control protection to be placed. An Erosion Control Plan shall be prepared cooperatively from this inspection in a form approved by the Engineer. The inspection shall be scheduled at the preconstruction conference. The inspection shall be carried out and the Erosion Control Plan prepared prior to beginning any work which will disturb existing drainage or require erosion control.

Erosion control measures as indicated in the Erosion Control Plan, or as directed by the Engineer shall be installed on the project site prior to beginning any construction activities which will potentially create erodible conditions. Erosion control devices shall be in place and approved by the Engineer as to proper placement and installation prior to beginning other work. Erosion control protection for Contractor borrow pits, equipment storage sites, plant sites, haul roads, and other sites shall be installed by the Contractor and approved by the Engineer prior to beginning construction activities at each site.

The Engineer has the authority to limit the surface area of erodible earth material exposed by clearing and grubbing, excavation, borrow and embankment operations, and to direct the Contractor to provide immediate permanent or temporary erosion control measures. The Contractor shall incorporate all permanent erosion control features into the project at the earliest practicable time to minimize the need for

temporary controls. Cut slopes shall be permanently seeded and mulched as the excavation proceeds to the extent considered desirable and practical. Seeding done outside the specified seeding dates shall be approved by the Engineer in writing.

In case of repeated failure on the part of the Contractor to take steps prescribed by the Engineer to control erosion, the Engineer reserves the right to employ outside assistance or to use his/her own forces to provide the necessary corrective measures. Such incurred direct costs plus project engineering costs will be charged to the Contractor and deducted from any compensation due, or which may become due the Contractor under the contract.

**280.04 Temporary Erosion Control Systems.** This work may be constructed of hay or straw bales, silt filter fence, mulch barrier, aggregate barriers, excavation, seeding, mulch or of other appropriate methods and materials, separately or in combination, as approved, by the Engineer.



(a) Temporary Ditch Checks. This system consists of the construction of temporary ditch checks to prevent siltation, erosion or scour of various ditches and drainageways. The ditch checks shall be constructed of sufficient length and height to prevent over topping or washing out.

Aggregate ditch checks shall be constructed by depositing the material and shaping it in a manner approved by the Engineer. If the ditch check is within the clear zone and the road is open to traffic, the traffic approach slope of the aggregate shall be graded to a 1:4(V:H) slope.

Hay or straw bales shall be installed in a backfilled trench 75 mm (3 inches) deep. Where more than 1 row is used, the bales shall be staggered to cover joints. Where bales are to be staked, a minimum of 2 stakes per bale shall be used.

(b) Perimeter Erosion Barrier. This system consists of a continuous barrier adjacent to an area of construction to intercept water borne silt and prevent it from leaving the area of construction. The barrier shall be of sufficient length and height to capture all construction runoff.

When silt filter fence is used for this purpose, the silt filter fence shall be supported on posts at least 2 m (6 ft.) in length and spaced on 1.5-m (5-ft.) centers. The fabric shall be installed in a backfilled trench 150 mm (6 inches) deep and securely attached to the posts by any method approved by the Engineer.



- (c) Inlet and Pipe Protection. This system consists of placement of protection surrounding inlets, pipe inlets and outlets and in similar locations as required to intercept water borne silt and prevent it from entering the drainage system.
- (d) Sedimentation Basins. This system consists of excavating and maintaining temporary basins at pipe inlets or outfalls, in ditches and in drainageways to capture water borne silt and prevent it from exiting the construction area. The outfall of these basins is usually protected by perimeter erosion barrier to capture remaining silt.
- (e) Temporary Ditches. This system consists of constructing temporary ditches

- to intercept water borne silt and runoff at locations designated on the plans or directed by the Engineer.
- (f) Temporary Seeding and Mulch. This system consists of installing a temporary grass cover and/or mulch cover over designated areas of the right of way to prevent sheet erosion of areas that are to be altered during a later construction phase. The seeding shall conform to the requirements of Section 250 for Seeding, Class 7, and may be done with a hand seeder or other approved methods and covered with a drag or harrow. The temporary mulch cover shall conform to the requirements of Section 251 for Mulch, Method 1 or Mulch, Method 2. The method to be used will be as designated in the contract.
- **280.05 Maintenance.** The temporary erosion control systems installed by the Contractor shall be properly maintained as directed by the Engineer to control siltation at all times during the life of the contract. This work shall include repair of the various systems, removal of trapped sediment and cleaning of any silt filter fabric. Accumulated silt in sediment basins shall be removed at any time the basin becomes 75 percent filled. Any additional materials and work required by the Engineer will be measured and paid for as specified. If the Contractor fails to maintain the temporary erosion control systems as directed by the Engineer, the Engineer may at the expiration of a period of 48 hours, after having given the Contractor written notice, proceed to maintain the systems as deemed necessary, and the cost thereof will be deducted from any compensation due, or which may become due the Contractor under this contract.
- **280.06 Method of Measurement.** In the event that temporary erosion and pollution control measures are ordered by the Engineer due to the Contractor's negligence, carelessness, or failure to install permanent controls, the work shall be performed by the Contractor at his/her own expense. Temporary erosion and pollution control work ordered by the Engineer, which is not attributed to the Contractor's negligence, carelessness or failure to install permanent controls, will be measured for payment according to the following:
  - (a) Excavation for Sediment Basins and Temporary Ditches. The volume of excavation for sediment basins and temporary ditches will be measured for payment in place and the volume computed in cubic meters (cubic yards).
  - (b) Temporary Ditch Checks. Temporary ditch checks will be measured for payment as individual items and the unit of measurement will be each.
  - (c) Perimeter Erosion Barrier. Perimeter erosion barrier will be measured for payment in meters (feet) in place.
  - (d) Inlet and Pipe Protection. Inlet and pipe protection will be measured for payment as individual items and the unit of measurement will be each.
  - (e) Temporary Seeding. Temporary seeding will be measured for payment in hectares (acres) of surface area seeded as specified in Article 250.08.



- (f) Temporary Mulch. Temporary mulch will be measured for payment in metric tons (tons) of surface area mulched.
- (g) Fence. Fence installed in the construction of hay or straw ditch checks or other barriers will be measured for payment in meters (feet) of fence in

- place. Existing right-of-way fence left in place and incorporated in these systems will not be measured for payment.
- (h) Aggregate. Aggregate used to control erosion will be measured for payment by weight in metric tons (tons). The aggregate shall be weighed on platform scales meeting the approval of the Engineer.

**280.07 Basis of Payment.** Temporary erosion control systems ordered by the Engineer, the need for which is not attributed to the Contractor's negligence, carelessness or failure to install permanent controls, will be paid for according to the following:

- (a) Excavation for Sediment Basins and Temporary Ditches. Excavation for the construction of sediment basins and temporary ditches will be paid for all the contract unit price per cubic meter (cubic yard) for EARTH EXCAVATION FOR EROSION CONTROL.
- (b) Temporary Ditch Checks. Temporary ditch checks will be paid for at the contract unit price each for TEMPORARY DITCH CHECKS, regardless of the types of material or configurations used.
- (c) Perimeter Erosion Barrier. Perimeter erosion barrier will be paid for at the contract unit price per meter (foot) for PERIMETER EROSION BARRIER, regardless of the type used.
- (d) Inlet and Pipe Protection. Inlet and pipe protection will be paid for at the contract unit price each for INLET AND PIPE PROTECTION, regardless of the type or configuration used.
- (e) Temporary Seeding. Temporary seeding will be paid for at the contract unit price per hectare (acre) for SEEDING, CLASS 7, according to Article 250.09.



- (f) Temporary Mulch. Temporary mulch for erosion control will be paid for at the contract unit price per metric ton (ton) for MULCH, METHOD 1, or MULCH, METHOD 2, according to Article 251.06.
- (g) Fence. Fence installed in the construction of hay or straw ditch checks or other barriers will be paid for at the contract unit price per meter (foot) for FENCE (EROSION CONTROL). Existing right-of-way fence left in place and incorporated in these systems will not be paid for as a separate item, but shall be considered as included in the contract price bid for the various temporary erosion control systems involved.
- (h) Aggregate. Aggregate used to control erosion will be paid for at the contract unit price per metric ton (ton) for AGGREGATE (EROSION CONTROL).
- (i) Maintenance. Maintenance of temporary erosion control systems, including repair of the various systems, removal of entrapped sediment and cleaning of any silt filter fabric, will be paid for according to Article 109.04. The sediment shall be removed as directed by the Engineer during the contract period and disposed of according to Article 202.03.

The above pay items for temporary control systems shall include all materials and labor necessary to install, remove and dispose of the systems as shown on the plans

or as directed by the Engineer. All salvageable temporary erosion control items shall be removed and become the property of the Contractor at the completion of the contract.

If the Contractor is required to install any temporary erosion control system for which the contract does not include a bid item, such system(s) will be paid for according to Article 109.04.

## **SECTION 281. RIPRAP**

- **281.01 Description.** This item shall consist of furnishing, transporting and placing a protective course of stone, broken concrete or precast concrete blocks laid as riprap for erosion protection, sediment control or rockfill on slopes or in channels.
- **281.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 Materials:

	Item Article	e/Section
(a)	Stone for Erosion Protection, Sediment Control and Rockfill	1005.01
(b)	Concrete Blocks and Broken Concrete for Riprap	1005.02
(c)	Filter Fabric Material	1080.03

## **CONSTRUCTION REQUIREMENTS**

- **281.03** Foundation Preparation. The bed for the riprap shall be trimmed and shaped to allow the finished surface to conform to the lines specified. At the toe of the slope, the riprap shall commence on a continuation of the slope after excavation to accommodate the full depth of fabric, bedding layer, and riprap specified.
- **281.04 Placing.** After the Engineer has approved the foundation preparation, a layer of filter fabric shall be installed. Installation of the filter fabric will be required under stone riprap gradations 4, 5, 6, and 7 for all uses, and under concrete block, broken concrete, and stone or broken concrete dumped riprap when used for erosion protection. The fabric shall be installed according to the plans and as specified in Section 282. A bedding layer will be required for stone riprap gradations 4, 5, 6, and 7, and for concrete block, broken concrete, and stone or broken concrete dumped riprap when used for erosion protection. No bedding layer will be required for concrete block riprap, broken concrete riprap or for stone or broken concrete dumped riprap when used for sediment control or rockfill.
  - (a) Stone Riprap. Gradation 1 shall be used as the bedding material for Gradations 4 and 5. Gradation 2 shall be used as the bedding material for Gradations 6 and 7. Bedding material shall be spread uniformly on the filter fabric in a satisfactory manner to the neat lines specified. Placing of material by methods which will tend to segregate particle sizes within the bedding will not be permitted. Any damage to the surface of the bedding base or the filter fabric during placing of the bedding shall be repaired before proceeding with the work. Compaction of the bedding layers will not be required but it shall be finished to present a reasonably even surface free from mounds, windrows, or depressions. The thickness of the stone riprap layer shall be according to the following table:

Art. 281.04 Riprap

Gradation	Min. Thickness	Bedding Thickness
1 & 2	150 mm (6 inches)	-
3	200 mm (8 inches)	-
4	400 mm (16 inches)	150 mm (6 inches)
5	550 mm (22 inches)	200 mm (8 inches)
6	650 mm (26 inches)	250 mm (10 inches)
7	750 mm (30 inches)	300 mm (12 inches)

Stone shall be placed on the bedding layer in such manner as to produce a reasonably well-graded mass of rock with the minimum practicable percentage of voids providing maximum interlocking of stones and shall be constructed to the lines and grades shown.

The riprap shall not be placed or dropped from a height of more than 300 mm (1 ft.). The stone riprap shall be placed to its full course thickness in one operation and in such a manner as to avoid displacing the bedding material. Placing of material shall begin at the lower elevations, progressing up the slope and, from the center outward, unless otherwise determined by the Engineer. The larger stones shall be well distributed and the entire mass of stones in their final position shall be roughly graded to conform to the gradation specified. There shall be no abrupt changes in the riprap surface. All tapers between minimum thickness and any high points shall be at a uniform rate. The finished riprap shall be free from objectionable pockets of small stones and clusters of larger stones. Placing riprap in layers will not be permitted. Placing riprap by dumping into chutes or by similar methods likely to cause segregation of the various sizes will not be permitted. The desired distribution of the various sizes of stones throughout the mass shall be obtained by selective loading of the material at the quarry or other source, by controlled dumping of successive loads during final placing, or by other methods of placement which will produce the specified results. Rearranging of individual stones by mechanical equipment or by hand will be required to the extent necessary to obtain a reasonably well-graded distribution of stone sizes as specified above.

- (b) Concrete Block Riprap. Bedding placement, when required, shall be as described for stone riprap in (a). Concrete blocks shall be laid with the joints perpendicular to the slope. The individual blocks in each horizontal course shall be placed when possible so that they will break joints with the blocks in the course below. For noninterlocking blocks, each tenth course shall be embedded into the slope with the long dimension of the blocks perpendicular to the slope.
- (c) Broken Concrete Riprap. Bedding placement, when required, shall be as described for stone riprap in (a). The individual pieces of broken concrete shall be placed by hand, flat upon the slope. The pieces shall be laid with close joints, the larger pieces being placed in the lower courses. Any open joints shall be filled with spalls thoroughly rammed into place. The finished surface of the riprap shall present an even, close surface, true to the lines, grades and sections given.
- (d) Stone or Broken Concrete Dumped Riprap. Bedding placement, when required, shall be as described for stone riprap in (a). The dumped riprap shall be a minimum of 300 mm (12 inches) thick. Placement shall begin

at the lower elevations and progress up the slope. Dumped riprap of stone or broken concrete, as specified, shall be placed on slopes or in channels by mechanical means. End dumping of material using mechanical equipment will be permitted provided the larger stone or pieces of broken concrete are well-distributed and the entire mass, in final position, is roughly graded to conform to the gradation specified. Placement by dumping into chutes or other methods likely to cause segregation will not be permitted.

The finished riprap shall be reasonably free from objectionable pockets of small pieces and clumps of large pieces, and the surface shall be shaped to follow the grade of the slope or channel. Rearranging of the dumped stone or broken concrete by mechanical equipment or by hand will be required only to the extent necessary to remove objectionable pockets or clumps of small or large material, and to obtain a surface reasonably true to line and grade.

**281.05 Disposal of Surplus Material.** Surplus or waste material resulting from the riprap operations shall be disposed of by the Contractor, at his/her own expense, according to Article 202.03.



- **281.06 Method of Measurement.** Riprap will be measured for payment in place, and the area computed in square meters (square yards). The area for measurement will include the upper sloped surface of the riprap and upper horizontal surface of the toe anchor.
- **281.07** Basis of Payment. This work will be paid for at the contract unit price per square meter (square yard) or metric ton (ton) for STONE RIPRAP or STONE DUMPED RIPRAP of the class (stone quality and gradation) specified, CONCRETE BLOCK RIPRAP, BROKEN CONCRETE RIPRAP, or BROKEN CONCRETE DUMPED RIPRAP.

Filter fabric for use with riprap will be measured and paid for according to Section 282.

Excavation and aggregate bedding will not be paid for as separate items but shall be considered as included in the contract unit price bid for the Riprap.

#### SECTION 282. FILTER FABRIC FOR USE WITH RIPRAP

- **282.01 Description.** This work shall consist of furnishing all materials, equipment and labor, and performing the required operations for the installation of geotechnical filter fabric in conjunction with riprap on prepared subgrades or embankment foundations.
- **282.02 Materials.** Materials shall meet the requirements of the following Article of Section 1000 Materials:

	Item	Article	/Section
(a)	Filter Fabric Material		1080.03

## CONSTRUCTION REQUIREMENTS

- **282.03 General.** The weight of the filter fabric used will depend on the gradation of riprap specified. For riprap gradations 4 and 5, a fabric weight of 200 g/m<sup>2</sup> (6 oz. per sq. yd.) shall be used. A fabric weight of 270 g/m<sup>2</sup> (8 oz. per sq. yd.) shall be used with riprap gradations 6 and 7. The filter fabric shall be stored above the ground inside and away from sunlight at temperatures less than 60 °C (140 °F.) and protected from any and all damage. The exposure of the filter fabric to the elements between laydown and cover shall be a maximum of 14 days.
- **282.04 Subgrade Preparation.** The depth and area of excavation for the filter placement shall not exceed the dimensions necessary to properly place the filter fabric. Prior to the installation of the fabric, the foundation surface shall be cleared of debris, sharp objects and trees. Tree stumps shall be cut to the level of the prepared ground surface. If stumps cannot be cut to the ground level, they shall be completely removed. All wheel tracks, ruts, or surface irregularities in excess of 50 mm (2 inches) in depth shall be graded smooth or otherwise filled with soil to provide a reasonably smooth surface. The filter fabric shall not be placed until the prepared bed has been approved by the Engineer.
- **282.05 Placement.** Filter fabric shall be placed in the manner and at the locations shown on the plans or as directed by the Engineer. At the time of installation, fabric shall be rejected if it has defects, rips, holes, flaws, deterioration, or damage incurred during manufacture, transportation or storage.

The fabric shall be unrolled directly over the area as shown on the plans. Fabric may be installed either by hand or mechanical methods provided the surface is not rutted. The fabric shall be laid loosely and free of tension, stress, folds, wrinkles, or creases. The fabric shall be turned down and buried 600 mm (2 ft.) at all exterior limits, except where a stone filled key trench is provided below natural ground. As the riprap proceeds up the grade, the top edge of the fabric shall be buried as a part of the last operation. The fabric shall be placed with the long dimension parallel to the centerline of the channel or shoreline unless otherwise directed by the Engineer. Overlaps in the fabric should be placed so that any upstream strip of fabric will overlap the downstream strip, and the upslope roll should overlap the downslope roll.

Fabric of insufficient width or length to fully cover the specified area shall be lapped or sewn. The minimum laps for lap only areas are 300 mm (12 inches) and for sewn areas are 100 mm (4 inches).

If sewn, the fabric shall be stitched at a minimum rate of 4 stitches per 25 mm (1 inch) with high-strength polyester, polypropylene, or kevlar thread. The seam strength shall be equal to or more than the minimum grab tensile strength of the fabric when tested wet according to ASTM D 4632.

**282.06 Securing Pins.** Securing pins for anchoring filter fabric shall be nominally 5-mm (3/16-inch) diameter steel bars, pointed at one end and fabricated with a head to retain a steel washer having an outside diameter of not less than 40 mm (1 1/2 inches). The length of the pin shall not be less than 300 mm (12 inches). Securing pins shall be inserted through both strips of overlapped cloth at not greater than the following intervals along a line through the midpoint of the overlap.

Slope	Pin Spacing
Steeper than 1:3(V:H) 1:3(V:H) to 1:4(V:H)	600 mm (2 ft.) 900 mm (3 ft.)
Flatter than 1:4(V:H)	1.5 m (S ft.)

Each securing pin shall be pushed through the fabric until the washer bears against the fabric and secures it firmly to the foundation. Additional pins regardless of location shall be installed as necessary to prevent any slippage of the filter fabric. If the Engineer determines that the proper lap is not being maintained by the use of pins, then sewing will be required at no extra cost to the Department.

- **282.07 Protection.** The fabric shall be protected at all times during construction from contamination by surface runoff and any fabric so contaminated shall be removed and replaced with uncontaminated fabric. Any damage to the fabric during its installation or during placement of riprap shall be replaced or repaired by the Contractor at his/her own expense. If the fabric is damaged during installation, the material around the rupture shall be removed and the damaged area covered with a patch of fabric using an overlap of 1.2 m (4 ft.) in each direction. The patch shall be held in position with securing pins.
- **282.08 Method of Measurement.** Filter fabric will be measured for payment in place and the area computed in square meters (square yards). The buried edges of the fabric will not be measured for payment and the overlap joints and seams will be measured as a single layer of material.
- **282.09** Basis of Payment. This work will be paid for at the contract unit price per square meter (square yard) for FILTER FABRIC FOR USE WITH RIPRAP, which price shall include preparation of the subgrade beneath the fabric, and all materials and labor necessary for proper installation of the fabric.

#### SECTION 283. FLEXIBLE DITCH LINING

- **283.01 Description.** This work shall consist of furnishing and installing permanent flexible linings in roadside ditches consisting of fiber mat, or stone aggregate.
- **283.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 Materials:

	Item	Article/Section
(a)	Fiber Mat	1081.10(e)
	Wire Staples	
(c)	Wood Stakes	1081.10(d)
(d)	Aggregate Ditch	1005.01
(e)	Filter Fabric	1080.03

#### CONSTRUCTION REQUIREMENTS

**283.03 Fiber Mat.** All surfaces to be protected shall be prepared according to Sections 212 and 250. The mat shall be placed within 24 hours after seeding

operations have been completed on the areas specified. Prior to placing the mat, the areas to be covered shall be relatively free of all rocks or clods over 40 mm (1 1/2 inches) in diameter and all sticks or other foreign material which would prevent the close contact of the mat with the seed bed. If, as a result of a rain, the prepared seed bed becomes crusted or eroded, or if eroded places, ruts or depressions exist for any reason, the Contractor will be required to rework the soil until it is smooth and to reseed such areas that are reworked. After the area has been properly shaped, fertilized and seeded, the mat shall be laid out flat, evenly and smoothly without stretching the material.

Fiber mat used as a ditch lining shall be applied with the lengths running parallel to the flow of water. Where more than one width is required, a lap joint of not less than 75 mm (3 inches) shall be used, with the upslope width on top. All lap joints, junction slot overlaps and upslope edges shall be stapled or staked at intervals of 900 mm (3 ft.) or less.

An anchor slot shall occur at the upslope and downslope ends of the fiber mat placement. This is accomplished by burying at least 300 mm (12 inches) of the end of the mat vertically in a slot dug in the soil. The mat shall be secured in the anchor slot by 300-mm (12-inch) long stakes at intervals of 1 m (3 ft.) or less prior to burying. The soil shall be firmly tamped against the fiber mat in the slot.

Junction slots shall be used to join the ends of successive lengths. For junction slots, the upslope end of each strip of fiber mat shall be buried at least 200 mm (8 inches) in a slot dug in the earth. Soil shall be firmly tamped against the fiber mat in the slot. The ends of the fiber mat shall overlap at least 300 mm (12 inches) with the upslope section on top.

Check slots shall be constructed by placing a tight fold at least 200 mm (8 inches) vertically into the soil. Check slots shall be spaced so that a check or junction slot occurs within each 8 m (25 ft.).

Upslope edges of fiber mat used as ditch lining shall terminate on 150 mm (6 inch) wide horizontal shelves running parallel to the ditch for the full length of the ditch.

Fiber mat used as a swale lining shall be applied with the lengths running parallel with the slope. Adjacent widths shall be overlapped a minimum of 75 mm (3 inches). All overlaps and lateral edges shall be stapled or staked at intervals of 1 m (3 ft.) or less.

Anchor slots, junction slots and check slots shall be as provided under the ditch lining application above.

When the swale lining terminates in a lined ditch, the fiber mat shall lap a minimum of 150 mm (6 inches) over the ditch lining and be stapled or staked at intervals of 1 m (3 ft.) or less.

After the fiber mat has been installed in place, a layer of dry, fine topsoil shall be applied to fill the voids of the mat. This layer should not be any deeper than the mat and care should be taken so as not to disturb the seed bed or mat.

**283.04** Aggregate Ditch. The stone aggregate ditch shall be constructed on a filter fabric as 1 layer of dumped stone without any bedding material.

The filter fabric shall be constructed according to Section 282 except that the edges along the centerline of the ditch shall be turned down and buried 150 mm (6 inches), the upstream and downstream shall be turned down and buried 300 mm (12 inches), and securing pins at overlaps shall be inserted at each edge of the ditch bottom and at intervals of not greater than 1.5 m (5 ft.) extending up the slopes.

The aggregate layer shall be a minimum of 300 mm (12 inches) thick and placed to the lines and grades as shown on the plans, or as directed by the Engineer. The placement of the aggregate shall begin at the lower elevation and proceed up the slope in such manner to construct a reasonably well graded mass of stone free from objectionable pockets of small stones and clusters of large stones. Arranging of stones may be required to the extent necessary either mechanically or by hand to obtain a well graded distribution of stone sizes and grade lines. Disturbed soil surfaces not covered with stone aggregate shall be seeded, fertilized and mulched according to Sections 250 and 251.

**283.05 Method of Measurement.** Fiber mat will be measured for payment in place and the area computed in square meters (square yards) of actual surface area protected.

Aggregate ditch will be measured for payment in metric tons (tons) according to Article 311.08(b).

**283.06** Basis of Payment. This work will be paid for at the contract unit price per square meter (square yard) for FIBER MAT and per metric ton (ton) for AGGREGATE DITCH.

Filter fabric will be measured and paid for according to Section 282.

## **SECTION 284. GABIONS AND SLOPE MATTRESS**

- **284.01 Description.** This item shall consist of furnishing, transporting and placing a protective course of stone confined by wire baskets used as retaining walls, slope paving, bank protection, weirs, drop structures or outfall structures.
- **284.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 Materials:

	Item	Article	/Section
(a)	Stone for Erosion Control (Note 1)		1005.01
	Gabions and Slope Mattress		
(c)	Wire Fasteners		1006.36
(d)	Anchor Stakes	1006.04,	1006.18
(e)	Filter Fabric Material		1080.03

Note 1. The stone shall meet the requirements of Quality Designation A and shall not contain objectionable quantities of dirt, sand, clay or rock fines. The stone shall be well graded with maximum stone dimensions ranging between 100 mm and 200 mm (4 inches and 8 inches). No stone shall have a minimum dimension less than 75 mm (3 inches) and the ratio of maximum to minimum dimension shall not be greater than 2.

## CONSTRUCTION REQUIREMENTS

284.03 Fabric Gabions and Mattresses. Baskets shall be fabricated in such a manner that the sides, ends, lid, and diaphragms can be assembled at the construction site into rectangular baskets of the sizes specified and shown on the drawings. Baskets furnished by the manufacturer shall be of uniform size. Baskets shall be of single unit construction, i.e., the base, lid, ends, and sides shall be either woven into a single unit or one edge of these members connected to the base section of the basket in such a manner that strength and flexibility at the point of connection is at least equal to that of the mesh. Where the length of the basket exceeds 1 1/2 its horizontal width, the basket shall be equally divided by diaphragms, of the same mesh and gauge as the body of the baskets, into cells whose length does not exceed the horizontal width. The basket shall be furnished with the necessary diaphragms secured in proper position on the base in such a manner that no additional tying at this juncture will be necessary. Baskets shall be assembled by tying or fastening all untied edges. The tying wire shall be tightly laced around every fabric opening along the seams in such a manner that single and double loops are alternated. If wire fasteners are used, they shall be installed at approximately 100 mm (4 inch) to 150 mm (6 inch) intervals, but not less than one fastener for each fabric opening along the ioint.

Sufficient wire fasteners, lacing, and connecting wire to match the basket material shall be supplied with the baskets for all fastening operations carried out in the construction of the gabion and mattress work.

All perimeter edges of the baskets, including end panels and the diaphragms, if any, shall be mechanically selvedged in such a way as to prevent any unravelling of the fabric and to develop the full strength of the fabric. The wire used for the selvedge shall have a diameter greater than that of the wire used to form the fabric.

- **284.04 Foundation Preparation.** The bed for the gabions or slope mattress shall be trimmed and shaped to conform to the line and grade shown on the plans and as directed by the Engineer.
- **284.05 Placing.** After the Engineer has approved the foundation preparation, a layer of filter fabric shall be installed. Installation of the filter fabric will be required under both the gabions and the slope mattress, and behind the gabions. The filter fabric shall shall be installed according to the plans.

The baskets shall be placed to conform with plan details. The stone material shall be placed in close contact in the unit so that maximum fill is obtained.

Empty basket units shall be assembled individually and placed on the approved surface to the lines and grades as shown on the drawings or as directed by the Engineer, with the sides, ends, and diaphragms erected in such a manner to insure the correct position of all creases and that the tops of all sides are level. All adjoining empty gabion units shall be secured to the adjoining unit in order to obtain a monolithic structure. Wire fasteners may be used in lieu of lacing wire for forming individual baskets, joining empty baskets together and closing lids. Binding wire or wire fasteners shall be used along vertical reinforced edges and top selvedges. When baskets are stacked, the base of the top basket shall be tightly wired or fastened to the lower basket at front and back. Lacing of adjoining basket units shall be accomplished by continuous stitching with alternating single and double loops at intervals of not more than 125 mm (5 inches). All lacing wire terminals shall be

securely fastened. If wire fasteners are used, a fastener shall be provided at each fabric opening along the joint. A minimum of 6 fasteners are required per 1 m (3 ft.) seam, 3 fasteners are required per 450 mm (18 inches) seam and 2 fasteners per 300 mm (1 ft.) seam.

The initial line of basket units shall be placed on the prepared surface in a direction parallel to stream flow, and partially filled to provide anchorage against deformation and displacement during filling operations. After adjoining empty basket units are set to line and grade and common sides with adjacent units thoroughly laced or fastened, baskets shall be placed in tension and stretched to remove any kinks from the fabric and to a uniform alignment. The stretching of empty basket units shall be accomplished in such a manner as to prevent any possible unraveling.

Stone filling operations shall carefully proceed with placement by hand or machine so as not to damage the wire coating, to assure a minimum of voids between the stones, and the maintenance of alignment throughout the filling process. Undue deformation and bulging of the fabric shall be corrected prior to further stone filling. To avoid localized deformation, the basket units in any row are to be filled in stages consisting of maximum 300 mm (12 inch) courses. Baskets 450 mm (18 inches) tall or more shall use connecting wires in each internal compartment after each 225 mm (9 inch) or 300 mm (12 inch) layer except when the lid is closed over the last layer. For baskets 450 mm (18 inches) tall, the connecting wires shall be installed between the 225 m (9 inch) layers of stone. The 1 m (3 ft.) tall baskets shall have connecting wires installed between each 300 mm (12 inch) layer of stone. These wires shall connect the front face to the back face. All connecting wires shall be looped around 2 fabric openings and the ends of the wires securely twisted to prevent loosening. For end units, 2 additional connecting wires shall be placed at each level perpendicular to the normally required connecting wires.

At no time shall any cell be filled to a depth exceeding 300 mm (12 inches) more than the adjoining cell. The maximum height from which the stone may be dropped into the basket units shall be 1 m (3 ft.).

Along all exposed faces, the outer layer of stone shall be carefully placed and arranged by hand to insure a neat and compact appearance. The last layer of stone shall be leveled with the top of the gabion to allow for the proper closing of the lid and to provide an even surface that is uniform in appearance. Lids shall be stretched tight over the stone fill using only an approved lid closing tool, until the lid meets the perimeter edges of the front and end panels. Using crowbars or other single point leverage bars for lid closing shall be prohibited. The lid shall then be tightly tied with lacing wire along all edges, ends, and internal cell diaphragms by continuous stitching with alternating single and double loops at intervals not more than 125 mm (5 inches). Wire fasteners may be used in lieu of lacing wire. Special attention shall be given to see that a projections or wire ends are turned into the baskets. Where shown on the drawings or as directed by the Engineer, or where a complete gabion unit cannot be installed because of space limitations, the basket unit shall be cut, folded, and wired together to suit existing site conditions. The fabric must be cleanly cut and the surplus fabric cut our completely, or folded back and neatly wired to an adjacent gabion face. The assembling, installation, filling, lid closing, and lacing of the reshaped gabion units shall be carried out as specified above.

The slope mattress shall be anchored as shown on the plans. If the Contractor elects to drill for the soil anchor stakes, care shall be taken to avoid drilling holes to a greater depth than is necessary to place the top of the finished stake slightly above

the top of the finished mattress.

The Contractor may assemble, partially fill and tie together mattress units on the subgrade provided they can be placed on the slope without abrading the zinc or vinyl coating on the wire mattress or permanently distorting the shape of the mattress in transporting and installing the units on the slope. All prefabrication procedures shall be subject to the approval of the Engineer.

The Contractor shall maintain the gabions or slope mattress until final acceptance and any material displaced by any cause shall be replaced by the Contractor at his/her own expense.

- **284.06 Disposal of Surplus Material.** Surplus or waste material resulting from the gabion or slope mattress operations shall be disposed of by the Contractor at his/her own expense according to Article 202.03.
- **284.07 Method of Measurement.** Gabions will be measured for payment in place and the volume computed to the nearest cubic meter (cubic yard), based on the actual lengths, widths and depths. Slope mattress will be measured for payment in place and the area computed in square meters (square yards) based on the actual lengths and widths over which placement is made.
- **284.08** Basis of Payment. This work will be paid for at the contract unit price per cubic meter (cubic yard) for GABIONS of the type material specified or at the contract unit price per square meter (square yard) for SLOPE MATTRESS of the type material and thickness specified, which price shall include all labor materials and equipment for constructing the work complete in place, except filter fabric.

Filter Fabric will be measured and paid for as provided in the plans.

## SECTION 285, FABRIC FORMED CONCRETE REVETMENT MATS

- **285.01 Description.** This work shall consist of constructing fabric formed concrete revetment mats as shown on the plans.
- **285.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 Materials:

	Item	Article/Section
(a)	Portland Cement (Note 1)	Article/Section 1001
(b)	Fine Aggregate (Note 2)	1003.02
(c)	Water	1002
(d)	Pozzolan	1010
(e)	Concrete Admixtures	1021.03
(f)	Fabric	1080.04

- Note 1. Portland cement shall be Type I or Type II.
- Note 2. Aggregate grading shall be reasonably consistent and shall be well graded from the maximum size which can be conveniently handled with available pumping equipment.

**285.03 Equipment.** Mixing and pumping equipment used in preparation and handling of the grout shall be approved by the Engineer. All oil or other rust inhibitors shall be removed from the mixing drums, stirring mechanisms, and other portions of the equipment in contact with the grout before the mixers are used. The pumping equipment shall have a variable flow rate to provide enough pressure for pumping without breaking the fabric.

## **CONSTRUCTION REQUIREMENTS**

**285.04 General.** The slopes or surfaces to be protected shall be prepared and graded to such an extent that they are normally stable in the absence of erosive forces. Any fill material required to restore the slopes to original condition shall be approved by the Engineer. A fabric envelope in a mat configuration shall be positioned over these surfaces and filled with a pumpable sand/cement grout in such a way as to form a stable mat of suitable weight and configuration.

**285.05 Proportioning and Mixing Grout.** The structural grout shall consist of a mixture of portland cement, fine aggregate and water so proportioned and mixed as to provide a pumpable slurry. Pozzolan and grout fluidizer may be used at the option of the Contractor. The structural grout shall have an air content of not less that 6 percent nor more than 9 percent of the volume of the grout. The mix shall obtain a compressive strength of 17 MPa (2500 psi) at 28 days when made and tested according to the Manual of Instructions for Concrete Proportioning Engineers. All materials shall be accurately measured by volume or mass (weight) as they are fed into the mixer. The quantity of water shall be such as to produce a grout having a pumpable consistency. Time of mixing shall be not less than one minute. If agitated continuously, the grout may be held in the mixer or agitator for a period not exceeding 2 1/2 hours in temperatures below 21 °C (70 °F.), and for a period not exceeding 2 hours at higher temperatures. If there is a lapse in a pumping operation, the grout shall be recirculated through the pump or through the mixer drum (or agitator) and pump.

**285.06** Placement of Fabric and Grout. Prior to grout injection, the fabric shall be positioned at its design location. Each panel shall be a continuous or monolithic unit for its full width, including the trench portion.

Each panel shall consist of 2 or more mill-widths of open selvage construction; the 2 upper layers shall be joined together by sewing, and the 2 bottom layers shall be sewn together at the edges. Where adjacent panels cannot be joined in this manner, they shall be lapped a minimum of 600 mm (2 ft.). In no case will simple butt-joints, either sewn or unsewn, be permitted. The ends and upper limits of the fabric mat shall be placed in a trench of suitable width as shown on the plans.

Small cuts shall be made in the fabric to allow for the insertion of the grout hose or grout nozzle. Grout shall be introduced into the space between the layers of fabric and shall be injected in such a way that excessive pressure on the fabric envelope is avoided. Starting at the lowest elevation and working up the slope, the grout shall be injected in such a way that the distance from the point of injection to the end of the panel is not greater than 9 m (30 ft.). After grouting has been completed, the void between the trench wall and filled fabric shall be backfilled.

Holes in the fabric left by the removal of the grout hose or inserts shall be temporarily closed by inserting a piece of burlap or similar material. The burlap shall be removed when the mortar is no longer fluid and the surface is firm to hand



# Art. 285.06 Fabric Formed Concrete Revetment Mats

pressure. Foot traffic on the filled revetment mats shall be limited to an absolute minimum for one hour after pumping in order to reduce indentation.

- **285.07 Method of Measurement.** Fabric formed mats will be measured in place and the area computed in square meters (square yards). The area for measurement will include the upper, sloped surface of the mat. The portion of the mat in trenches shall be considered as included in the cost of the mat and will not be measured for payment. No allowance will be made for overlaps.
- **285.08** Basis of Payment. This work will be paid for at the contract unit price per square meter (square yard) for FABRIC FORMED CONCRETE REVETMENT MATS.

#### SECTION 300. SUBGRADES, SUBBASES AND BASE COURSES

#### SUBGRADE

# **SECTION 301. SUBGRADE PREPARATION**

- **301.01 Description.** This work shall consist of preparing the completed subgrade. It shall include shaping and final compaction of the earth for the construction of subbase, base, and surface courses.
- **301.02 Equipment.** Equipment shall meet the requirements of the following Articles of Section 1100 Equipment:

	Item	Article/Section
(a)	Tandem Roller	1101.01
(b)	Three-Wheel Roller	1101.01
(c)	Tamping Roller	1101.01
	Pneumatic-Tired Roller	
(e)	Subgrade Planer	1103.08
(f)	Subgrade Machine	1103.09
(g)	Heavy Subgrade Template	1103.10

#### CONSTRUCTION REQUIREMENTS

**301.03 General.** If the rough grading has been included in a previous contract, the roadbed shall be restored by removing all vegetation, filling all depressions, and smoothing the surface. If the contract includes rough grading and surfacing, the rough grading shall be completed as far in advance of the construction of the surfacing as feasible. Soft and unstable material that will not compact when rolled or tamped shall be removed and disposed of according to Article 202.03, and replaced with material approved by the Engineer, according to Articles 205.05 and 205.06.

The entire subgrade shall be compacted to not less than 95 percent of the standard laboratory density. Densities will be determined as provided in Article 205.06. All holes, ruts, soft places and other defects shall be corrected. In no case shall the surface course, base course, gutter, curb, or combination curb and gutter be placed on soft or unstable material, or over areas that are not drained in a manner satisfactory to the Engineer. If the subgrade is dusty or muddy, operations shall be delayed until it is in a condition satisfactory to the Engineer.

In cut sections, the Contractor responsible for the rough grading shall take the following steps in an effort to obtain not less than 95% of the standard laboratory density in the subgrade.

- (a) Step 1. Cut plan ditches which drain the area at least to grade. This shall be done at least two weeks prior to Step 2.
- (b) Step 2. Air dry the top 200 mm (8 inches) of subgrade. This procedure shall include at least two 200 mm (8-inch) depth processings utilizing discs or tillers each day for 3 consecutive good drying days.
- (c) Step 3. Recompact the layer processed in Step 2 to achieve not less than

95% density, or until at least 9 passes of a roller which has demonstrated ability to obtain the density on adjacent earthwork have been made.

When the work listed in the steps above has been accomplished and a subgrade in compliance with the Department's "Subgrade Stability Manual" has not been attained, the Engineer will make a determination as to whether additional drying and recompaction will be needed to obtain the stable subgrade or whether the ground and soil conditions warrant more extensive treatments. Extra work required after the steps listed above to obtain a satisfactory subgrade will be paid for according to Article 109.04.

The subgrade shall be constructed so that after being compacted, it will conform to the alignment, grade, and cross section shown on the plans, and as required by the Engineer. Surplus excavated material resulting from grading and shaping the subgrade shall be disposed of as directed by the Engineer. If additional material is required, it shall be obtained from the right of way if possible and approved by the Engineer. Placement shall be according to Articles 205.05 and 205.06.

Where rolling of the subgrade is required, any areas which are inaccessible to a roller shall be compacted by either a mechanical or hand tamper meeting the approval of the Engineer.

Equipment of such weight, or used in such a way as to cause a rut in the finished subgrade of 50 mm (2 inches) or more in depth, shall be removed from the work, or the rutting otherwise prevented.

- **301.04** Aggregate Base Course and Aggregate Surface Course, Type A. The subgrade shall be compacted by rolling with the three-wheel, tandem, or pneumatic-tired roller. The rolling shall extend at least 300 mm (12 inches) beyond each edge of the proposed base course, unless otherwise required by the Engineer. No base course, gutter, curb, or combination curb and gutter shall be placed until the subgrade has been approved by the Engineer.
- **301.05** Aggregate Surface Course, Type B. The subgrade will not have to be rolled prior to placement of the aggregate surface course, Type B. No surface course, gutter, curb, or combination curb and gutter shall be placed until the subgrade has been approved by the Engineer.
- **301.06** Bituminous Concrete Base Course and Pavement (Full-Depth) and PCC Base Course and Pavement. The work shall be extended to at least 450 mm (18 inches) beyond each edge of the proposed base course or pavement. When a subbase is being placed under the base course or pavement, the work shall be extended to include the area being covered by the subbase material.

Prior to final shaping, the subgrade shall be compacted with a pneumatic-tired, three-wheel or tandem roller. Three-wheel or tandem rollers shall weigh from 5.5 metric tons (6 tons) to 9 metric tons (10 tons) and shall weigh not less than 35 N/mm (200 lb./inch) nor more than 57 N/mm (325 lb./inch) of width of the roller.

The subgrade shall be brought to true shape by means of a subgrade planer and/or subgrade machine according to the following:

- (a) Either the subgrade planer or the subgrade machine shall be used when:
  - (1) PCC pavement or base course is constructed on the subgrade or

subbase using forms.

- (2) Bituminous base course is constructed.
- (b) The subgrade machine shall be used when:
  - PCC pavement or base course is constructed on the subgrade or subbase using the slip form method.
  - (2) Continuously reinforced pcc pavement is constructed on the subbase or subgrade.
  - (3) Bituminous concrete pavement (full-depth) is constructed.

The subgrade shall be tested for crown and elevation by means of a heavy subgrade template. High and low areas shall be brought to the correct elevation. After the subgrade has been corrected, it shall be rechecked.

When portland cement concrete is being placed directly on the subgrade, the subgrade shall be moist, but not muddy, at the time of placing the concrete. If required by the Engineer, the prepared subgrade shall be saturated with water the previous night, or not less than 6 nor more than 20 hours prior to the placing of the concrete. If the subgrade subsequently becomes too dry, it shall be sprinkled again ahead of placing the concrete, in such a manner as not to form mud or puddles of water.

The Contractor shall have at all times a minimum of 1 day's production of subgrade prepared ahead of the location at which the concrete is being placed.

The subgrade will be checked and approved by the Engineer before construction of the subbase, base course or pavement is started on any portion of the work. The Engineer may stop construction work at any time the subgrade is not in proper condition for the placing of the subbase, base course or pavement, or if the required amount has not been prepared ahead.

- **301.07** Gutters, Curbs, and Combination Curb and Gutter. The subgrade shall be compacted and finished to a firm, smooth surface in a manner approved by the Engineer.
- **301.08 Drainage.** The subgrade shall be kept drained during the placing and compacting of the surface, base course, or subbase. If berms of earth are deposited along the area upon which the subbase, base, or surface course is being placed, provision shall be made for surface drainage by cutting lateral ditches through the berms of earth.
- **301.09 Maintenance.** The finished subgrade shall be maintained in a smooth and compacted condition until the subbase, base course, surface course, gutter, curb, or combination curb and gutter is placed.
- **301.10 Method of Measurement.** When the contract includes both grading and paving, subgrade preparation will not be measured for payment.
  - (a) Contract Quantities. The requirement for use of contract quantities shall be according to Article 202.07(a).

## Subgrade Preparation

- (b) Measured Quantities. When the contract includes paving on a pregraded section, subgrade preparation will be measured for payment in units of 30 m (100 ft.) in horizontal distances along baselines. No allowance will be made for variable width roadways.
- **301.11 Basis of Payment.** When the contract includes grading and paving, subgrade preparation will not be paid for separately but shall be considered as included in the cost of to the various types of surface course, base course, subbase, gutter, curb, or combination curb and gutter included in the contract.

When the contract includes paving on a pregraded section, subgrade preparation will be paid for at the contract unit price per unit for SHAPING AND GRADING ROADWAY, which price shall include the excavation for removal or placement of all material within 50 mm (2 inches) of the grade and cross section shown on the plans or established by the Engineer. Excavation for the removal or placement of material outside this 50-mm (2-inch) tolerance will be paid for according to Article 109.04.

## **SECTION 302. LIME MODIFIED SOILS**

- **302.01 Description.** This work shall consist of the construction of a lime modified soil layer composed of soil, lime and water.
- **302.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 Materials:

	Item Art	icle/Section
(a)	Water	1002
	Hydrated Lime	
(c)	Hydrated By-Product Lime	1012.02
(d)	By-Product Lime for Lime Modified Soils	1012.03

**302.03 Equipment.** Equipment shall meet the requirements of the following Articles of Section 1100 - Equipment:

	Item Article	e/Section
(a)	Rollers (Note 1)	1101.01
(b)	Distributor (Note 2)	
(c)	Rotary Speed Mixer	1101.06
(d)	Disk Harrow	1101.02
(e)	Subgrade Planner	1103.08
	Subgrade Machine	
(g)	Heavy Subgrade Template	1103.10



- Note 1. Three-wheel rollers and tandem rollers, when used, shall weigh not less than 5.5 metric tons (6 tons) nor more than 11 metric tons (12 tons) and shall have a compression on the drive wheels of not less than 35 N/mm (190 lbs. per inch) nor more than 70 N/mm (400 lbs. per inch) width of roller.
- Note 2. Distributor for spreading lime shall be cyclone, screw-type or pressure manifold type as approved by the Engineer.

#### CONSTRUCTION REQUIREMENTS

**302.04 General.** Lime shall not be applied to or mixed with frozen soil. The amount of lime modified soil constructed shall be limited to that which can be covered with subbase, base or pavement within the same construction season, unless otherwise permitted by the Engineer.

# 302.05 Proportioning.

- (a) Samples. The Contractor, at his/her own expense, shall provide a minimum of 5 kg (10 lbs.) of lime and 45 kg (100 lbs.) of soil proposed to be used at least 30 days prior to the construction of the lime modified soils.
- (b) Mix Design. Lime will be proportioned within a range of 2 6 percent of soil (oven-dry basis). The required proportion of lime will be established by the Engineer prior to construction, using samples of the proposed soil and lime, and the Department's laboratory design procedure for lime modified soil. The Engineer reserves the right to make such adjustments of lime proportioning as are considered necessary during the progress of the work within the range specified, without additional compensation to the Contractor.

Source or type of lime shall not be changed during the progress of the work without permission of the Engineer.

**302.06 Spreading of Lime.** The surface of the grade shall be lightly scarified or disked prior to distribution of the lime. The lime shall then be distributed uniformly over the surface. The Engineer may reject any procedure which does not provide even distribution of lime.

Lime shall not be applied when wind conditions are such that blowing lime becomes objectionable to adjacent property owners or creates a hazard to traffic on adjacent highways.

The spreading of lime shall be limited to that amount which can be incorporated into the soil within the same working day. In the event that rain intervenes causing cessation of work and exposure of the lime to washing or blowing, the Engineer may require additional lime to be spread at no cost to the Department.

- **302.07 Mixing.** The lime, soil, and water (if necessary) shall be thoroughly blended by rotary speed mixers or a disk harrow. The mixing shall continue until it has been determined by the Engineer that a homogeneous layer of the required thickness has been obtained. The loose thickness of a single lime modified layer shall not exceed 200 mm (8 inches) if a disk harrow is used, or 350 mm (14 inches) if a rotary speed mixer is used.
- **302.08 Compaction.** Compaction of the mixture shall begin as soon as is practicable after mixing. In no case shall compaction be started later than 3 days after mixing unless approved by the Engineer. If compaction is to be delayed, the surface of the lime modified soil shall be crown-graded and sealed by either blade dragging or light rolling immediately after mixing.

Compaction shall be continued until the lime modified layer has a density of not less than 95 percent of the standard dry density. The standard dry density of the lime

treated soil shall be determined from AASHTO T 99 (Method C). The field in-place dry density will be determined by the Engineer according to AASHTO T 191 or AASHTO T 238 and T 239, or by other methods approved by the Engineer.

Aeration by means of further mixing, or the addition of water and further mixing, may be required by the Engineer to achieve the required compaction.

**302.09 Finishing.** The final lift of lime modification shall be constructed approximately to the grade shown on the plans before spreading the lime. The final lift of lime modification shall be no less than 150 mm (6 inches) thick when compacted. When compaction of the final lift of lime modified soil is nearing completion, the surface shall be shaped to the required lines, grades and cross section, and compaction shall be continued until uniform and adequate density is obtained.

For bituminous concrete base course and pavement (full-depth) and portland cement concrete base course and pavement construction, the surface of the lime modified soil shall be brought to true shape and correct elevation according to Article 301.06, except that well compacted earth shall not be used to fill low areas.

## 302.10 Method of Measurement.

- (a) Contract Quantities. The requirements for the use of contract quantities shall conform to Article 202.07(a).
- (b) Measured Quantities. Processing lime modified soils will be measured in place and the area computed in square meters (square yards). The width for measurement will be as shown on the plans.

Water used will be measured in units of 1000 L (1000 gals.). A weigh ticket or meter ticket for each truck load shall be furnished to the Engineer. Scales or meters shall be approved by the Engineer.

Lime will be measured for payment in metric tons (tons). The lime shall be measured in trucks or freight cars. The Contractor shall furnish or arrange for use of scales of a type approved by the Engineer. If the lime is shipped in trucks, it shall be measured at the place of loading, at the place of unloading, or at such other place as the Engineer may designate. The Engineer may accept original signed freight bills in lieu of determining the mass (weight).

Should the Contractor's method of construction require extra earth excavation or embankment due to requiring more than one lift to construct the lime modified soil layer as shown on the plans, this extra earth excavation and embankment will not be measured for payment.

**302.11 Basis of Payment.** This work will be paid for at the contract unit price per square meter (square yard) for PROCESSING LIME MODIFIED SOILS of the thickness specified, per unit for WATER, and per metric ton (ton) for LIME.

#### SECTION 310. LIME STABILIZED SOIL MIXTURE

**310.01 Description.** This work shall consist of the construction of a lime stabilized soil mixture, composed of "reactive soil", lime and water which shall be considered as subbase.

**310.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 - Materials:

		cle/Section
(a)	Water 1002.01	- 1002.02
	Hydrated Lime (Note 1)	
(c)	Hydrated By-Product Lime	1012.02
(d)	Non-Hydrated By-Product Lime for Lime	
` ,	Stabilized Soil Mixture	1012.04
(e)	Soil (Note 2)	1012.04

Note 1. Quick lime, meeting the requirements for calcium lime stated in ASTM C 5, may be substituted if used in a slurry.

Note 2. The soil shall be a "reactive soil". "Reactive soils" are defined as those soils which when mixed thoroughly with at least 3 percent lime, compacted and cured for 48 hours at 49 °C (120 °F.) will exhibit a strength gain of at least 345 kPa (50 psi) greater than that obtained from similarly prepared untreated control specimens.

**310.03 Equipment.** Equipment shall meet the requirements of Article 302.03, except that three-wheel rollers and tandem rollers shall weigh not less than 5.5 metric tons (6 tons) nor more than 11 metric tons (12 tons) and shall have a compression on the drive wheels of not less than 35 N/mm (190 lbs. per inch) nor more than 70 N/mm (400 lbs. per inch) width of roller.



## CONSTRUCTION REQUIREMENTS

**310.04 General.** The lime stabilized soil mixture shall be constructed between April 15 and September 15, and placed only when the temperature of the subgrade measured 50 mm (2 inches) to 75 mm (3 inches) below the surface, is above 10 °C (50 °F.), and the air temperature in the shade is above 4 °C (40 °F.). In no instance shall lime be applied to or mixed with frozen soil. The amount of subbase course constructed shall be limited to that which can be covered by the succeeding pavement layer during the same construction season. If any of these conditions are not met, the Contractor shall remove and replace the affected portion of the work at his/her own expense.

**310.05 Proportioning.** The actual proportions of lime, soil and water will be determined according to the Department's design method (available on request) by the Engineer before work begins, utilizing the project soil(s) and the lime intended for use. The right is reserved by the Engineer to make such changes in proportions during the progress of the work as becomes necessary. In no case shall proportions or type of lime be changed during the progress of the work without written permission

of the Engineer.

- (a) Samples. The Contractor shall, at his/her own expense, submit to the Engineer a minimum of 11 kg (25 lbs.) of lime and 90 kg (200 lbs.) of subgrade soil which the Contractor proposes for use in the mixture. The lime, when sampled, shall be placed immediately in a sealed container and shall be kept sealed. Samples shall be delivered at least 45 days prior to the construction of the lime stabilized soil mixture. The samples, as submitted, will be tested for acceptance of the materials and used to determine preliminary proportions for the mixture composition.
- (b) Design. The lime and soil shall be proportioned within the limits of from 3 to 8 percent lime based on the dry weight of the soil. The mixture used shall provide a minimum laboratory average compressive strength of 690 kPa (100 psi).
- **310.06 Preparation of Subgrade.** If the roadway has been graded under a separate contract or is being graded under this contract, the area to be processed shall be shaped to the proper grade and cross section. All vegetation and other objectionable material shall be removed from within the limits of lime treatment.
- **310.07 Scarification and Pulverization.** If necessary, the soil to be processed shall be scarified or pulverized to the required treatment depth prior to the application of the lime. Precautions shall be taken to avoid forming furrows of loosened material below the depth specified for the lime stabilized soil mixture.
- **310.08** Lime Application. Lime (slurry or dry) shall be spread on that area where the initial mixing operations can be completed during the same working day. The surface of the grade shall be lightly scarified or disked prior to distribution of the lime (slurry or dry). The application of lime shall be accomplished by the methods hereinafter described as "Slurry Placing" or "Dry Placing".

Lime (slurry or dry) that has been exposed to the open air for a period of 6 hours or more shall be replaced by the Contractor at his/her expense.

- (a) Slurry Placing. Slurry Placing shall be restricted to either hydrated Type N or Quicklime, and it shall be prepared and transported to the roadbed by one of the following methods:
  - (1) Central Plant. Agitation shall be accomplished through integral paddles, recirculating pumps, compressed air, or a combination of these devices. The slurry distributor truck, hauling from the central plant, shall be equipped with a recirculating pump or agitator of sufficient size to keep the lime and water in a uniform mixture until spread.
    - The slurry produced shall consist of a minimum mixture of approximately 1 metric ton (1 ton) of lime to each 2000 L (500 gals.) of water (about 31 percent solution) and shall not contain more than 40 percent lime (by weight). It shall be placed within 24 hours after mixing.
  - (2) Jet Mixer. The portable jet slurry plant shall be capable of producing slurry instantaneously by jetting water approximately 500 kPa (75 psi)

and lime continuously in a 65:35 (by weight) ratio into a mixing bowl. This type of portable slurry plant generally eliminates the need for batching tanks. The distributor shall be equipped to keep the slurry agitated and in a uniform mixture if it cannot be spread on the embankment within 20 minutes of its preparation.

(3) Portable Batch Slaker. Slurry from the quicklime shall be prepared in an approved portable batch slaker. Quicklime, when coming into contact with a perspiring worker's skin, can cause burns; therefore, workers shall be suitably protected. Uniformity of the slurry shall be attained in each batch by adding the required amount of water, then the quicklime, and then agitating. The slurry produced shall not contain more than 40 percent lime (by weight). The distributor shall be equipped to keep the slurry agitated and in a uniform mixture if it cannot be spread on the embankment within 20 minutes of its preparation.

The lime slurry shall be distributed uniformly on the roadbed by gravity or pressure spray bars. The number of passes to apply the required amount of lime shall be approved by the Engineer.

(b) Dry Placing. Dry placing shall be restricted to either hydrated Type N or non-hydrated by-product lime. The lime (except quicklime) shall be spread uniformly by means of cyclone, screw, or pressure manifold type distributors at the rates directed by the Engineer.

The lime shall be distributed at a uniform rate and in such a manner as to reduce the scattering of lime by wind to a minimum and dry lime shall not be applied when wind conditions, in the opinion of the Engineer, are such that blowing lime becomes objectionable to traffic and adjacent property owners.

- **310.09 Mixing.** Prior to final compaction, lime stabilized mixture shall be pulverized to meet the gradation requirements as given below under Article 310.09(b). To meet this requirement, two-stage mixing shall be required for heavy clay soils. One-stage mixing may be permitted by the Engineer, provided that the requirements for final mixing are met. The required mixing procedure shall be as follows:
  - (a) Initial Mixing. The lime, soil, and water shall be thoroughly mixed and blended by an approved roadmixer or other approved equipment until a uniform mixture throughout the required depth and width is obtained in which all clods and lumps are reduced to a maximum of 50 mm (2-inch) diameter size. Water shall be added during the initial mixing operation in a sufficient quantity to bring the moisture content to at least 3 percentage points above optimum. When proper mixing has been accomplished, light rolling to seal the surface of the mixture shall be performed to minimize evaporation loss, lime carbonation, or to prevent wetting from heavy rains, and the mixture shall be left to undergo a conditioning period of at least 48 hours or as directed by the Engineer. The mixture shall be maintained in a moist condition throughout the entire conditioning period.
  - (b) Final Mixing. After the required conditioning period, the mixture shall be uniformly mixed by approved methods and maintained at approximately optimum moisture content as determined herein. If the lime stabilized soil

mixture contains clods, they shall be reduced by pulverization so that the lime treated soil will meet the following requirements:

Minimum passing	25 mm (1") sieve	. 100%
Minimum passing	4.75 mm (No. 4) sieve	. 60%

**310.10 Compaction.** Compaction of the mixture shall begin immediately after the final mixing or at a time when the final mixing pulverization requirements are met. Prior to the beginning of compaction, the mixture shall be in a loose condition for its full depth and width. The mixture shall then be uniformly compacted until the specified density has been obtained. Particular care shall be exercised to insure density along the edges of the section and adjacent to construction joints.

The compaction shall be continued until a density of not less than 95 percent of the standard laboratory density of the lime stabilized mixture as determined by AASHTO T 99 (Method C) has been achieved. Any portion of the lime stabilized soil mixture that has a density of less than 95 percent of the standard dry density shall be corrected or removed and replaced to meet this specification at the Contractor's expense. The in-place dry density shall be determined by the Engineer according to AASHTO T 191 or AASHTO T 238 and T 239, or by other methods approved by the Engineer.

**310.11 Finishing and Curing.** When initial compaction of the top layer of the lime stabilized soil mixture is nearing completion, the surface shall be shaped to the required lines, grades, and cross section, and compaction continued until uniform and adequate compaction is obtained. For bituminous concrete base course and pavement (full-depth) and portland cement concrete pavement and base course, the surface of the lime stabilized soil mixture shall be brought to true shape and correct elevation according to Article 301.06 except that well compacted earth shall not be used to fill low areas. The surface shall be maintained in a moist condition by means of a fine spray during all finishing operations. The lime treated soil shall be cured for a period of 7 days and maintained at a moisture content satisfactory for proper curing by sprinkling, or application of liquid bituminous material. During this period, no traffic shall be permitted on the completed work beyond that required for maintenance of curing moisture, or application of bituminous curing material.

The bituminous material used for curing shall be Emulsified Asphalt RS-1, RS-2, CRS-1, CRS-2, Liquid Asphalt RC-70, RC-250, MC-70, MC-250, and shall be applied at the rate of approximately 1 L/m² (0.20 gal. per sq. yd.) and shall be applied uniformly to the surface of the subbase by a pressure distributor to give complete coverage without excessive runoff. The exact rate of application and temperature will be specified by the Engineer. At the time this bituminous material is applied, the surface shall be tightly knit, free of all loose or extraneous material, and shall contain sufficient moisture to prevent penetration of the bituminous material.

- **310.12 Construction Joints.** Construction joints will not be required between each day's work unless there is a time lapse of 7 days or more between the processing of adjacent sections. If construction joints are required, they shall be formed by cutting back 1 m (3 ft.) into the completed work to form a vertical face. Otherwise, damage to completed work shall be avoided.
- **310.13 Maintenance.** The Contractor shall maintain, at his/her own expense, the entire lime stabilized soil mixture in a manner satisfactory to the Engineer.

Maintenance shall include immediate repairs of any defective or damaged portions of the mixture.

- **310.14 Method of Measurement.** This work will be measured for payment according to the following methods:
  - (a) Processing lime stabilized soil mixture will be measured for payment in place and the area computed in square meters (square yards) of lime stabilized soil mixture completed and accepted. The width of measurement will be the width from outside-to-outside of the completed lime stabilized soil mixture as shown on the plans or as determined by the Engineer.
  - (b) Water used for slurry, compacting, finishing and curing will be measured for payment in units of 1000 L (1000 gals.), as specified in Article 302.10.
  - (c) Lime incorporated in the lime stabilized soil mixture shall be measured for payment in metric tons (tons) as specified in Article 302.10, but payment will not be made for lime in excess of 105 percent of the amount specified by the Engineer.
  - (d) Bituminous materials will be measured for payment as specified in Section 1009.
- **310.15 Basis of Payment.** This work will be paid for at the contract unit price per square meter (square yard) for PROCESSING LIME STABILIZED SOIL MIXTURE, of the thickness specified; per metric ton (ton) for LIME; per liter (gallon) for BITUMINOUS MATERIALS; and per unit for WATER.

#### **SECTION 311. GRANULAR SUBBASE**

- **311.01 Description.** This work shall consist of furnishing, placing and compacting granular material on the prepared subgrade.
- **311.02 Materials.** Materials shall meet the requirements of the following Article of Section 1000 Materials:

ltem	Article/Section
(a) Subbase Granular Material	

**311.03 Equipment.** Equipment shall meet the requirements of the following Articles of Section 1100 - Equipment:

	Item	Article/Section
(a)	Three-Wheel Roller	1101.01
(b)	Tandem Roller	1101.01
(c)	Pneumatic-Tired Roller	1101.01
ĺΑĺ	Vibratory Machine (Note 1)	
(e)	Subgrade Planer	1103.08
	Subgrade Machine	
	Heavy Subgrade Template	

Note 1. The vibratory machine shall meet the approval of the Engineer.

#### CONSTRUCTION REQUIREMENTS

- **311.04 Subgrade.** The subgrade shall be prepared according to Section 301 except Articles 301.04 and 301.05 will not apply.
- **311.05** Placing and Compacting Subbase Materials. Granular material used for subbase shall be placed to the widths and thicknesses shown on the plans and as follows:
  - (a) General. The granular material shall be placed and compacted as specified for the particular type of granular subbase. If any earth is worked into the granular material during the compacting or finishing operations, all granular material within the affected area shall be removed and replaced with new granular material. The Engineer may restrict hauling over the completed or partially completed work after inclement weather or at any time when the earth subgrade is soft and there is a tendency for the earth to work into the granular material.

The granular material shall be placed and compacted at least 3 days prior to the placement of pavement or base course.

If the moisture content is insufficient to maintain satisfactory compaction or to prevent segregation or raveling when hauling is permitted over the granular material, water shall be added as directed by the Engineer.

When construction of the granular subbase has been completed at a location, or when directed by the Engineer, the Contractor shall salvage the excess granular material outside the construction limits of the granular subbase. The salvaged granular material shall be carried forward and utilized in the construction of the granular subbase. The Contractor shall salvage the granular material in such a manner as to prevent segregation and the incorporation of earth.

(b) Subbase Granular Material, Type A. The granular material shall be uniform in gradation. Before the material is deposited on the roadway, it shall contain the amount of moisture required for compaction. The amount of moisture required shall be that determined by the Engineer for the material and the compaction methods being used. The water and granular material shall be mixed at a central mixing plant equipped with a mechanical mixing device and granular material and water measuring devices meeting the approval of the Engineer. Wetting the aggregate by jetting in cars, bins, stockpiles or trucks will not be permitted. Moisture shall be added to the material during compaction only when it is necessary to increase the percentage of moisture to obtain satisfactory compaction.

The subbase shall be constructed in layers not more than 100 mm (4 inches) thick when compacted, except that if tests indicate that the desired results are being obtained, the compacted thickness of any layer may be increased to a maximum of 200 mm (8 inches).

The granular material shall be deposited full-lane width with a mechanical spreader or spreader box of a type approved by the Engineer, in a manner that shall not cause segregation and that shall require minimum blading or

manipulation. The equipment and the method used shall be approved by the Engineer.

Each layer shall be compacted immediately after placing. The granular material shall be compacted to not less than 95 percent of the standard laboratory density.

The standard laboratory density shall be the maximum density determined according to AASHTO T 99 (Method A or C). A coarse particle correction according to AASHTO T 224 will be used with Method A and may be used with Method C.

The density of the compacted subbase will be determined by the Engineer at regular intervals according to AASHTO T 191 or AASHTO T 238 and T 239, or by other methods approved by the Engineer.

- (c) Subbase Granular Material, Type B. The subbase shall be constructed in layers not more than 150 mm (6 inches) thick when compacted, except that if tests indicate that the desired results are being obtained, the compacted thickness of any layer may be increased to a maximum of 200 mm (8 inches). Each layer of material shall be compacted in a manner approved by the Engineer. If the moisture content of the material is such that compaction satisfactory to the Engineer cannot be obtained, sufficient water shall be added, at the Contractor's expense, so that satisfactory compaction can be obtained.
- (d) Subbase Granular Material, Type C. The subbase shall be compacted to the satisfaction of the Engineer. The manner of placing and compacting the material shall be approved by the Engineer prior to starting this work.

**311.06** Finishing of Subbase for PCC Base Course and Pavement. The subbase shall be brought to true shape according to Article 301.06 except for the following.

The compacted subbase shall be placed above the plan elevation and the excess trimmed or cut with the subgrade machine. The Contractor shall determine the amount of excess subbase material necessary to meet this requirement. After the subbase has been brought to its true shape and correct elevation, the surface shall be wetted and rolled as directed by the Engineer with a three-wheel or tandem roller meeting the weight requirements specified in Article 301.06. The surface of the subbase shall be tested for crown and elevation by means of a template.

The Contractor shall have at all times a minimum of 1 day's production of subbase prepared ahead of the paving.

The subbase shall be moist at the time of placing the concrete. If required by the Engineer, the prepared subbase shall be saturated with water the previous night, or not less than 6 nor more than 20 hours prior to the placing of the concrete. If the subbase subsequently becomes too dry, it shall be sprinkled again ahead of placing the concrete, in such a manner as not to form puddles of water.

**311.07 Tolerance in Thickness.** The subbase shall be constructed to the thickness shown on the plans. Thickness determinations shall be made at such points as the Engineer may select. When the constructed thickness is less than 90

percent of the thickness shown on the plans, aggregate shall be added to obtain the specified thickness; however, the surface elevation of the completed subbase shall not exceed by more than 5 mm (3/16 inch) the surface elevation shown on the plans or authorized by the Engineer.

#### 311.08 Method of Measurement.

- (a) Contract Quantities. The requirements for the use of contract quantities shall conform to Article 202.07(a).
- (b) Measured Quantities. Granular subbase will be measured for payment in metric tons (tons), cubic meters (cubic yards) or square meters (square yards) of the thickness specified. Water required to be added for compaction on the grade will not be measured for payment, but shall be considered as included in the cost of the item of work being constructed. When the unit of measurement for the aggregate is metric tons (tons), the aggregate may be weighed in trucks or freight cars. The Contractor shall furnish or arrange for the use of scales of a type approved by the Engineer. If, at the time the Type A aggregate is weighed, it contains more than 3 percent of absorbed and free moisture by weight, a deduction for the amount of moisture in excess of this amount will be made in determining the pay quantity. Any aggregate that has been stockpiled will be weighed at the time it is incorporated into the work.

If the material is shipped in trucks, it may be weighed at the place of loading, at the place of unloading, or at such other place as the Engineer may designate. If the material is shipped in freight cars, the Engineer will accept the freight car weights, instead of scale weights, provided the Engineer is satisfied that the car weights are sufficiently accurate. In order to verify the car weights, the Contractor will be required to weigh the contents of at least 10 percent of the freight cars received each day, with a minimum of one car weight each day, over truck scales. If the truck weights do not verify the freight car weights, additional cars shall be weighed. In addition to this verification, the Contractor will be required to weigh the contents of any freight car that appears deficient in material. The Contractor shall furnish the original signed freight bill for each car.

When the unit of measurement for the aggregate is metric ton (ton), payment will not be made for aggregate in excess of 108 percent of the amount specified by the Engineer nor for aggregate placed outside the design width plus 150 mm (6 inches).

When the unit of measurement for the aggregate is cubic meter (cubic yard), the aggregate will be measured in place and the volume computed in cubic meters (cubic yards). The width and depth for measurement will be as shown on the plans.

When the unit of measurement for the aggregate is square meter (square yard), the aggregate will be measured in place and the area computed in square meters (square yards). The width for measurement will be as shown on the plans.

If the granular material removed during the subgrading operation is not carried forward and incorporated in the granular subbase, a deduction will be made for the

quantity not salvaged, except that no deduction will be made where the quantity not salvaged is less than 5 m<sup>3</sup>/100m (2 cu. yds. per station) or where cubic meters (cubic yards) or square meters (square yards) is the basis of payment.

**311.09 Basis of Payment.** Subbase Granular Material, Type A, Subbase Granular Material, Type B, and Subbase Granular Material, Type C, will be paid for at the contract unit price per metric ton (ton) for SUBBASE GRANULAR MATERIAL, TYPE A, SUBBASE GRANULAR MATERIAL, TYPE B, or SUBBASE GRANULAR MATERIAL, TYPE C, at the contract unit price per cubic meter (cubic yard) for SUBBASE GRANULAR MATERIAL, TYPE A, SUBBASE GRANULAR MATERIAL, TYPE B or SUBBASE GRANULAR MATERIAL, TYPE C; or at the contract unit price per square meter (square yard) of the thickness specified for SUBBASE GRANULAR MATERIAL, TYPE B, or SUBBASE GRANULAR MATERIAL, TYPE B, or SUBBASE GRANULAR MATERIAL, TYPE C, which price shall include performing all of the work specified.

#### **SECTION 312. STABILIZED SUBBASE**

- **312.01 Description.** This work shall consist of furnishing, placing and compacting a bituminous aggregate mixture, cement aggregate mixture, or pozzolanic stabilized mixture on the subgrade.
- **312.02 General.** The Contractor shall have the option within the time limitations and weather condition requirements of selecting the type of stabilization, except no change in type will be permitted unless authorized by the Engineer. When time limitations or weather conditions require that construction of a particular type of stabilization be discontinued, the Contractor shall proceed without delay with the construction of an alternate type which is permissible under the requirements of this Section. The Contractor will receive no additional compensation by reason of such change.

The amount of stabilized subbase constructed will be limited to that which can be surfaced during the current construction season.

The Contractor shall have at all times 1 day's production of subbase prepared ahead of the paying location.

Prior to placing the stabilized mixture, the subgrade shall be prepared according to Section 301 except Articles 301.04 and 301.05 will not apply, or Section 302 when specified.

#### **BITUMINOUS AGGREGATE MIXTURE**

**312.03 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 - Materials:

	Item	Article/Section
(a)	Aggregate (Note 1) (Note 2)	1004.04
(b)	RAP Material (Note 3)	1004.07
(c)	Bituminous Materials (Note 4)	1009.01-1009.05, 1009.09

Note 1. When blending is approved, fine material will be permitted in the blend provided that the Fine Aggregate is Class C quality or higher and the

Mineral Filler complies with the requirements of Article 1011.01. Blending proportions shall not be changed during the progress of the work without permission from the Engineer.

The gradation of the aggregate and/or the combined gradations of the aggregates shall conform to the required limits, except there shall not be less than 3% permitted to pass the 75  $\mu$ m (No. 200) sieve on an unwashed sample, as determined by the combined hot bin proportions.

Note 2. The Contractor may request approval to use aggregate not meeting the requirements of Article 1004.04(c); if approval is granted, all other requirements of Article 1004.04 and of Note 1 above shall apply.

The request for approval shall be submitted at least 4 weeks prior to production and shall include a laboratory test report listing the proposed source(s) of materials, percent and gradation(s) of the aggregate(s), asphalt type and content, and combined mix gradation with test data showing that the mix proposed meets the following design criteria:

- Minimum stability of 3.3 kN (750 lbs.) when tested according to AASHTO T 245.
- Maximum air void content of 6 percent in specimens prepared according to AASHTO T 245 as determined by the Department's high pressure air meter method or according to AASHTO T 209.

Additional Testing may be required to determine the acceptability of the mix proposed. If the mix proposed appears to be acceptable, the Engineer will observe the Contractor's operation prior to granting approval to assure that sound quality control practices are being used in manufacturing the aggregate. Failure of the mix to perform satisfactorily will be sufficient cause for rejection.

Once a mix is approved, the aggregate or combined aggregates shall be kept within the following tolerances:

Passing 25.0 mm (1 inch) sieve	0% *
Passing 12.5 mm (1/2 inch) sieve	±20%
Passing 4.75 mm (No. 4) sieve	±10%
	±15%
Passing 75 µm (No. 200) sieve	4% **

- \* All material shall pass the 25.0 mm (1 inch) sieve.
- \*\* Maximum of 12% passing 75 μm (No. 200) sieve.

Note 3. The original pavement or hot-mix bituminous materials need not contain crushed coarse aggregate.



Note 4. The bituminous material used in the mixture shall be asphalt cement Grade AC-2.5, AC-5, AC-10 or liquid asphalt MC-3000, except when RAP materials or aggregates not meeting the requirements of Article 1004.04(c) (Note 2 above) are used, liquid asphalt MC-3000 will not be permitted.

The Engineer reserves the right to specify the grade which shall be used. The bituminous material shall not be changed during the progress of the work without permission of the Engineer.

**312.04 Equipment.** Equipment shall meet the requirements of the following Articles of Section 1100 - Equipment:

	Item	Article/Section
(a)	Three-Wheel Roller (Note 1)	1101.01
(b)	Tandem Roller (Note 1)	1101.01
(c)	Self-Propelled Pneumatic-Tired Roller (Note 2)	1101.01
(d)	Trench Roller (Note 3)	1101.01
(e)	Hot-Mix Plant (Note 4)	1102.01
(f)	Mechanical Spreader (Note 5)	1102.03
(g)	Vibratory Roller	1101.01
(h)	Subgrade Planer	1103.08
(i)	Subgrade Machine	1103.09
	Heavy Subgrade Template	

Note 1. Three-wheel rollers and tandem rollers shall weigh not less than 5.5 metric tons (6 tons) nor more than 11 metric tons (12 tons), and shall have a compression on the drive wheels of not less than 35 N/mm (190 lbs.per inch) nor more than 70 N/mm (400 lbs. per inch) width of roller.



- Note 2. The self-propelled pneumatic-tired roller shall develop a compression of not less than 50 N/mm (300 lbs. per inch) of width of tire tread in contact with the bituminous surface.
- Note 3. Trench rollers shall be self-propelled and shall develop a compression of not less than 50 N/mm (300 lbs. per inch) nor more than 70 N/mm (400 lbs. per inch) of width on the compaction wheel.
- Note 4. For bituminous aggregate mixture, a hot-mix plant conforming to Article 1102.01 will be required except that Article 1102.01(a)(5), (8), and (9), Article 1102.01(b)(2), (6) and (7), and Article 1102.01(c)(1) and (5) shall not apply. When the aggregates are blended, aggregate feeders for each size shall be provided according to Article 1102.01(a)(5). If mineral filler is used, Article 1102.01(b)(2) also shall apply. A metering system for the collected dust will not be required. When a drier drum hot-mix plant is used to produce a bituminous aggregate mixture incorporating RAP material, the plant shall be suitably modified to produce recycled bituminous mixes in a manner approved by the Engineer.
- Note 5. The mechanical spreader shall be a spreading and finishing machine meeting the requirements of Article 1102.03 or it may be a type approved by the Engineer.

#### CONSTRUCTION REQUIREMENTS

**312.05 General.** The bituminous aggregate mixture shall be constructed only when the temperature in the shade is above 10 °C (50 °F.) when liquid asphalt is used. No mixture shall be placed on a frozen or muddy roadbed.

**312.06 Composition.** The aggregate and bitumen shall be proportioned within the following composition limits by weight:

<u>Ingredient</u>	Percent by Weight
Aggregate	94.0 to 96.0
Residual Bitumen	4.0 to 6.0*

\*Upper limit may be raised for the lower or top lifts if the Contractor elects to use a highly absorptive coarse and/or fine aggregate requiring more than 6% asphalt. The additional asphalt shall be furnished at no cost to the Department.

When RAP materials are being used, the RAP material, virgin aggregate(s) and asphalt cement shall be proportioned within the following composition limits by weight:

<u>Ingredient</u>	Percent by Weight
Virgin Aggregate(s)	46 - 93
RAP Material(s)	0 - 50
Mineral Filler (if required)	0 - 5
Asphalt Cement	4.0 - 7.0

The percentage of residual bitumen shall be controlled within  $\pm$  0.5 percent of the percentage set by the Engineer. The right is reserved by the Engineer to make such changes in proportions during the progress of the work, as the Engineer may consider necessary.

**312.07 Preparation of Materials.** When asphalt cement is used, it shall be transferred to the asphalt tanks and heated to a temperature of 120 °C (250 °F.) to 175 °C (350 °F.). If the loading temperature exceeds 175 °C (350 °F.), the asphalt shall not be used until it has cooled to 175 °C (350 °F.). When liquid asphalt is used, the bituminous material shall be heated to such a temperature that it will be workable when used. Wide variations in temperature which affect the quantity of asphalt delivered will not be permitted.

**312.08 Preparation of Mixture.** The aggregate shall be dried and heated in the revolving drier to a temperature of 120 °C to (250 °F.) to 165 °C (325 °F.), except when a drier drum hot-mix plant is used.

The aggregate and bituminous material used in the bituminous aggregate mixture shall be measured separately and accurately by weight or by volume. When the aggregate is in the mixer, the bituminous material shall be added and mixing continued for a minimum of 30 seconds and until a homogeneous mixture is produced in which all particles of the aggregate are coated. The mixing period, size of the batch or the production rate of continuous mixers shall be approved by the Engineer.

When liquid asphalt, MC-3000 is used, the foregoing requirements for the bituminous aggregate mixture using asphalt cement shall apply, except the ingredients for the bituminous aggregate mixture shall be heated and combined in such a manner and at such a temperature as to produce a mixture which when discharged from the pug mill shall be workable, but at no time shall the temperature of the mixture be more than 105 °C (225 °F.), or the flash point of the bituminous material. The aggregate shall be surface dry and shall contain not more than one percent of moisture by weight.

The ingredients shall be heated and combined in such a manner as to produce a bituminous mixture which when discharged from the mixer will, in general, vary not more than 10  $^{\circ}$ C (20  $^{\circ}$ F.) from the temperature set by the Engineer. When using asphalt cement, the temperature of the mixture shall not be more than 165  $^{\circ}$ C (325  $^{\circ}$ F.).

When RAP material(s) is used in the bituminous aggregate mixture, the virgin aggregate(s) shall be dried and heated in the drier to a temperature that will produce the specified resultant mix temperature when combined with the RAP material.

The heated virgin aggregates and mineral filler shall be combined with the RAP material in such a manner as to produce a bituminous mixture which when discharged from the mixer shall not vary more than 15 °C (30 °F.) from the temperature set by the Engineer. The combined ingredients shall be mixed for a minimum of 30 seconds or until a homogeneous mixture as to composition and temperature is obtained. For a batch type plant, the standard 15 seconds dry and 30 seconds wet mixing time should normally be used. Variation in wet and dry mixing times may be permitted, depending on the moisture content and amount of salvaged material used. The mix temperature shall not exceed 175 °C (350 °F.). Wide variations in the mixture temperature will be cause for rejection of the mix.

The final mixture(s) shall conform to the following Standard Deviations. These deviations will be verified by extraction tests of the final mixture. If these stipulations are not met, the amount of RAP material used shall be reduced by 10 percent increments per day until mix is produced meeting these requirements. When the Contractor is able to produce mixtures within these criteria for 3 consecutive days, the percent of RAP material may again be increased.

Selected Criteria (CA-6)	Standard Deviation1/	Tolerance2/
Passing 25 mm (1-inch) sieve Passing 12.5 mm (1/2-inch) sieve Passing 4.75 mm (No. 4) sieve Passing 1.18 mm (No. 16) sieve Passing 75 μm (No. 200) sieve Bitumen	5.0 6.5 5.5 4.5 2.5 0.5	90-100 60- 90 30- 56 10- 40 4- 12 3- 7
Selected Criteria (CA-10)	Standard Deviation1/	Tolerance2/
Passing 25 mm (1-inch) sieve Passing 12.5 mm 1/2-inch) sieve Passing 4.75 mm (No. 4) sieve Passing 1.18 mm (No. 16) sieve Passing 75 μm (No. 200) sieve Bitumen	6.5 6.0 5.0 2.5 0.5	100 65- 95 40- 60 15- 45 5- 13 3- 7

Selected Criteria (CA-12)	Standard Deviation1/	Tolerance2/
Passing 12.5 mm (1/2-inch) sieve	5.0	90-100
Passing 9.5 mm (3/8-inch) sieve	4.0	75- 95
Passing 4.75 mm (No. 4) sieve	5.0	50- 70
Passing 1.18 mm (No. 16) sieve	4.5	25- 45
Passing 75 µm (No. 200) sieve	2.5	5- 13
Bitumen	0.5	3- 7

- 1/ Represents the Standard Deviation of the overall population.
- 2/ Individual tests shall be between these tolerances.

Bituminous concrete Class I, Mixture A, B or C, may be used in leveling the subbase and in areas where small quantities of subbase are required. The Engineer reserves the right to specify the mix to be used.

**312.09 Transportation.** Transportation of bituminous aggregate mixtures shall conform to Article 406.14, except when asphalt cement is used in the mixture, no truck insulation or covering will be required during inclement weather if the mixture can be delivered and placed so that the temperature of the mixture behind the spreader is 95 °C (200 °F.) or higher.

**312.10 Placing and Compacting.** After the subgrade has been compacted and is acceptable to the Engineer, the bituminous aggregate mixture shall be spread upon it with a mechanical spreader. The thickness of mixture spread shall be such as to provide a maximum compacted layer of 150 mm (6 inches) provided the required density is obtained. The surface of each layer shall be clean and dry before succeeding layers are placed.

As soon as practical after the layer has been spread, it shall be compacted. The density shall be obtained by an approved vibratory compactor and a roller or by the use of two rollers, except that the compaction may be obtained using equipment which meets the approval of the Engineer provided the density and other requirements contained herein are met. Rollers shall be operated at a speed of not more than 50 m per minute (175 ft. per minute). After compaction, the first layer shall have a density of not less than 88 percent of the theoretical density. Subsequent layers shall be compacted to not less than 90 percent of theoretical density. In small, variable and/or confining areas not to exceed 2500 m² (3000 sq. yds.) or 300 m (1000 ft.) per day, only one roller will be required. In any case, if the density of a layer is less than required, additional compaction and/or the use of an additional roller will be required.

The theoretical density will be determined by the high pressure air meter or, at the option of the Engineer, it may be computed from the saturated surface dry specific gravity of the aggregate and the specific gravity of the asphalt at 25 °C (77 °F.).

The density of each of the finished layers of bituminous aggregate mixture will be obtained by approved nuclear methods or from specimens furnished by the Contractor as specified in Article 406.16, except that when liquid asphalt MC-3000 is used, the Engineer may elect to determine the density according to AASHTO T 191 or AASHTO T 238 and T 239, or by other methods approved by the Engineer. The cost of the work required in taking and transporting the specimens, and in refilling the holes caused by the removal of the specimens will not be paid for separately, but shall be included in the unit price bid for the type of work specified.

The bituminous aggregate mixture shall be delivered at a temperature of 110 °C (225 °F.) to 165 °C (325 °F.), except that when a drier drum hot-mix plant is used, the minimum delivery temperature may be 95 °C (200 °F.).

When liquid asphalt MC-3000 is used, the foregoing requirements for placing and compacting the bituminous aggregate mixture containing asphalt cement shall apply, except no specific delivery temperature for the bituminous mixture will be required.

Any areas of the subbase which have been damaged shall be repaired by the Contractor at his/her own expense and to the satisfaction of the Engineer.

**312.11 Finishing.** After completion of compaction of the top lift of bituminous aggregate mixture, the subbase, for its entire width, shall be brought to true shape according to Article 311.06 except that wetting and additional rolling will not be required.

#### **CEMENT AGGREGATE MIXTURE**

**312.12 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 - Materials:

	Item	Article/Section
(a)	Portland Cement (Note 1)	1001.01 - 1001.06
(b)	Water	1002.01 - 1002.02
(c)	Aggregate (Note 2)	1004.04

Note 1. Only Type I or Type IA portland cement conforming to Article 1001.01 shall be used. Bulk cement may be used provided the equipment for handling the cement is approved by the Engineer.

Note 2. The aggregate shall meet the following gradation requirements:

Passing 25.0 mm (1 inch) sieve	100%
Passing 12.5 mm (1/2 inch) sieve	60-100%
Passing 4.75 mm (No. 4) sieve	55-75%
Passing 2.36 mm (No. 8) sieve	40-65%
Passing 75 µm (No. 200) sieve	5-15%

When blending is approved, fine material will be permitted in the blend provided that the fine aggregate is Class C quality or higher and the mineral filler complies with the requirements of Article 1011.01. Blending proportions shall not be changed during the progress of the work without permission from the Engineer.

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**312.13 Equipment.** Equipment shall meet the requirements of the following Articles of Section 1100 - Equipment:

Item /	Article/Section
(a) Three-Wheel Roller (Note 1)	1101.01
(b) Tandem Roller (Note 1)	1101.01
(c) Tamping Roller (Note 2)	1101.01
(d) Pneumatic-Tired Roller	1101.01
(e) Trench Roller (Note 3)	1101.01
(f) Vibratory Roller	1101.01
(g) Subgrade Planer	1103.08
(h) Subgrade Machine	1103.09
(i) Heavy Subgrade Template	

Note 1. Three-wheel rollers and tandem rollers shall weigh from 5.5 metric tons (6 tons) to 11 metric tons (12 tons) and shall have a compression on the drive wheels of not less than 35 N/mm (190 lbs. per inch) nor more than 70 N/mm (400 lbs. per inch) width of roller.



- Note 2. In addition to the requirements of Article 1101.01, the tampers shall be long enough to penetrate within 25 mm (1 inch) of the prepared subgrade on the initial rolling.
- Note 3. Trench rollers shall be self-propelled and shall develop a compression of not less than 50 N/mm (300 lbs. per inch) nor more than 70 N/mm (400 lbs. per inch) of width on the compaction wheel.

#### **CONSTRUCTION REQUIREMENTS**

- **312.14 General.** The cement aggregate mixture (CAM) shall be placed only when the air temperature in the shade is above 4 °C (40 °F.). No cement aggregate mixture shall be deposited on a frozen or muddy subgrade.
- **312.15 Composition.** The Contractor shall, at his/her own expense, submit to the Engineer a minimum of 11 kg (25 lbs.) of cement and 70 kg (150 lbs.) of aggregate which the Contractor proposes to use in the mixture at least 60 days prior to the construction of the stabilized subbase. Samples of the materials shall be taken under the supervision of the Engineer. The quantity of portland cement to be added to the aggregate shall be not less than 5 nor more than 8 percent of the oven dry weight of the aggregate. The actual proportions of cement, water and aggregate material will be set by the Engineer before work begins and will be based on tests conducted on mixtures composed of the samples of the constituent materials furnished by the Contractor. The cement content will be determined in the laboratory according to AASHTO T 135 and AASHTO T 136 and shall be such that the loss in weight will not be more than 10 percent after 12 cycles of wetting and drying and freezing and thawing.
- **312.16 Mixing.** The constituents of the mixture shall be accurately proportioned and thoroughly mixed in a mechanical mixer at a central mixing plant. The control of the mixture shall be of such accuracy that the quantity of cement shall be within  $\pm 0.3$  percentage points of the amount set by the Engineer.

The measuring devices for proportioning the mixture, either by volume or by

weight, shall be of such accuracy that the proportions of the mixture will be maintained within the tolerances set forth in this Specification. The equipment used must be provided with means, meeting with approval of the Engineer, for calibration and check tests of the measuring devices.

In all plants, the water shall be proportioned by weight or volume and there shall be means by which the Engineer may readily verify the amount of water per batch or the rate of flow for continuous mixing.

The Contractor shall provide a platform scale and make arrangements for the use of a certified truck scale of sufficient capacity for calibration and periodic check tests of the feeders or measuring devices as needed during the production.

The mixer shall be capable of producing a uniform mixture. Mixing operations shall be continued until all ingredients are distributed evenly throughout the mixture and a uniform mixture, free of segregation, satisfactory to the Engineer, is obtained. The mixer shall be capable of discharging the mixture without undue segregation.

The moisture content at the time of mixing shall be such that the moisture content at the time of compaction will be within 80 to 110 percent of the optimum moisture determined.

**312.17 Placing and Compacting.** The construction requirements for Subbase Granular Material, Type A, as stipulated in Section 311 shall apply to the construction of the cement aggregate mixture, except as stated. References to granular material in Section 311 shall be construed to include cement aggregate mixture.

The cement aggregate mixture shall be spread for the full width of the subbase.

Depositing and spreading operations shall be conducted so that the total time elapsing from the time water is added to the mixture until compaction is started will be less than 60 minutes. The compaction operations must be started within 30 minutes from the time the material is deposited on the roadbed.

The type, size and number of compactors, and the rate of their operations, shall be such that the section being processed will be fully compacted within 2 hours of the time that the water is added to the mixture.

If, for any reason, construction operations are delayed or suspended and the Engineer orders any loose or uncompacted material removed and disposed of, the Contractor shall perform this work at his/her own expense.

The cement aggregate subbase may be constructed in one layer. If the density requirement cannot be complied with by placement in a single layer, then the mixture shall be constructed in two approximately equal layers. The first layer shall be maintained in a moistened condition by means of a fine spray until the succeeding layer is placed. Just prior to placing the second layer, the upper 13 mm (1/2 inch) of the existing layer shall be scarified.

The density of the full depth of each compacted layer shall be 100 percent of the standard dry density as determined by AASHTO T 134 on the field mixture, unless the Contractor requests a variance of the first day's cement aggregate mixture placement.

The Department may consider a variance to approve the Contractor's request to establish a mix and procedures providing that the following conditions are agreed to

before starting work:

- (a) The mix shall consist of aggregate meeting the requirement for cement aggregate mixtures and 7 percent cement.
- (b) A minimum compaction of 98 percent will be accepted provided adjustments in mix or procedures are implemented to achieve a final compaction of 100 percent before the end of the day.
- (c) No variance will be permitted after the first day's placement and 100 percent compaction will be required for all subsequent work.
- (d) If the compaction does not comply with this requirement, the condition shall be corrected or the material replaced to meet the specifications.

The density will be determined for compliance with these specifications by the Engineer according to AASHTO T 238 - Method B and AASHTO T 239, AASHTO T 191, or by other methods approved by the Engineer.

The cement aggregate mixture within the section being processed shall be constructed the full width and depth and the surface shall be trimmed and finished within a single working day.

No cement aggregate mixture may be salvaged.

- **312.18 Finishing.** When initial compaction of the top layer of the cement aggregate mixture is nearing completion, the surface shall be shaped to the required lines, grades and cross section according to the requirements of Article 311.06, and compaction continued until uniform and adequate compaction is attained. The moisture content of the surface material shall be maintained by means of a fine spray at or slightly above its optimum during all finishing operations and until the curing material is applied.
- **312.19 Protection and Cover.** After the cement aggregate mixture has been finished, it shall be protected against drying for a period of 7 days by applying a bituminous material. The bituminous material shall be applied as soon as possible after the completion of finishing operations, but in no event shall the finished cement aggregate mixture remain without cover for more than 24 hours. The equipment used for wetting the finished cement aggregate mixture with water or to apply a bituminous protective cover shall be of such limited weight that its use will not cause marring or rutting of the subbase.

The bituminous material used as a protective cover shall be Emulsified Asphalt RS-1, RS-2, CRS-1, CRS-2, Liquid Asphalt RC-70, RC-250, MC-70, MC-250 or High Float Emulsion (HFE) 60, 90, 150 and shall be applied at the rate of approximately 1 L/m² (0.20 gal. per sq. yd.) uniformly to the surface of the subbase by a pressure distributor to give complete coverage without excessive runoff. The exact rate of application and temperature will be specified by the Engineer. At the time the bituminous material is applied, the surface shall be tightly knit, free of all loose or extraneous material, and shall contain sufficient moisture to prevent penetration of the bituminous material. If needed, water shall be applied to fill the surface voids immediately before the bituminous cover is applied. Should it be necessary for construction equipment or other traffic to use the bituminous covered cement aggregate mixture before the bituminous material has hardened sufficiently to prevent pickup, sufficient sand shall be applied to prevent pickup.

Any finished or completed portion of the subbase which is traveled by construction equipment, or by other traffic, shall be protected in such a manner as to prevent the equipment or other traffic from marring or damaging the completed work.

At any time when the air temperature may be expected to reach the freezing point during the protection period, the subbase shall be protected from freezing with not less than 150 mm (6 inches) of loose, dry straw for 7 days after placement or until the cement aggregate mixture has hardened.

After the 7-day protection period, the straw shall be removed and disposed of according to Article 202.03.

**312.20 Construction Joints.** At the end of each day's construction, or when construction operations are delayed or suspended and the Engineer so orders, a straight transverse construction joint shall be formed by cutting back into the completed work to form a vertical face. Damage to completed work shall be avoided.

#### POZZOLANIC STABILIZED MIXTURE

**312.21 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 - Materials:

(a)	Item Water	Article/Section
(a) (b)	Aggregate (Note 1)	1004.04
	Lime	
(d)	Portland Cement (Note 2)	1001
(e)	Pozzolan (fly ash)	1010.01, 1010.02
(f)	Water Reducing Admixture (Note 3)	1021
 (g)	Sand Cover	1003.01(a), 1003.01(e)
(h)	Bituminous Cure Material	1009.01-1009.05
		1009.07

## Note 1. The gradation requirements shall be as follows:

Passing 37.5 mm (1 1/2-inch) sieve	100%
Passing 25 mm (1-inch) sieve	90-100%
Passing 12.5 mm (1/2 inch) sieve	60-100%
Passing 4.75 mm (No. 4) sieve	40- 70%
Passing 425 μm (No. 40) sieve	0- 25%
Passing 75 μm (No. 200) sieve	
(gravel)	0- 10%
	0- 15%

Alternate gradations will be considered provided mixture design data is furnished to the Department for analysis. Specialized durability testing may be required for unique aggregate gradations or proposed combinations of materials for which the Department does not have historical performance data. Production gradation tolerances shall be as stated in Articles 1003.01 and 1004.01. The coarse or fine aggregate gradation which most nearly resembles the proposed gradation will be utilized for production tolerances.

Boiler Slag. In addition to the aggregates permitted in Article 1004.04, boiler

#### Stabilized Subbase

slag may be used. The slag shall be wet-bottom boiler slag produced as a by-product of a power plant burning pulverized bituminous coal. The slag shall be composed of hard durable particles and shall be free of excessive or harmful amounts of foreign substances. Boiler slag in an oven dry condition shall meet the following gradation requirements:

Passing 4.75 mm (No. 4) sieve	80-100%
Passing 2.00 mm (No. 10) sieve	55- 90%
Passing 425 μm (No. 40) sieve	0- 25%
Passing 75 μm (No. 200) sieve	0- 10%

## Note 2. Only Type 1 or 1A shall be used.

Note 3. A water reducing admixture may be used if permitted by the Engineer. No adjustments will be made in the required lime or cement and pozzolan contents for this addition.

The Contractor shall, at his/her own expense, submit to the Engineer a minimum of 10 kg (25 lbs.) of lime or cement, 25 kg (50 lbs.) of fly ash, and 50 kg (100 lbs.) of the aggregate which the Contractor proposes to use in the mixture. The lime, when sampled, shall immediately be placed in a sealed container and shall be kept sealed. Samples shall be furnished at least 60 days prior to the construction of the subbase. The submitted samples will be tested for individual acceptance, for making design mixes, and for determining a tentative placement cut-off date.

**312.22 Equipment.** Equipment shall meet the requirements of the following Articles of Section 1100 - Equipment:

	Item	Article/Section
(a)	Three-Wheel Roller (Note 1)	1101.01
(b)	Tandem Roller (Note 1)	1101.01
(c)	Tamping Roller (Note 2)	1101.01
(d)	Pneumatic-Tired Roller	
(e)	Trench Roller (Note 3)	1101.01
(f)	Vibratory Roller	1101.01
(g)	Pozzolanic Aggregate Mixture Equipment	1104.01
(h)	Mechanical Spreader (Note 4)	
(i)	Wheel Saw (Note 5)	
(j)	Membrane Curing Equipment (Note 6)	
(k)	Subgrade Planer	1103.08
(l)	Subgrade Machine	1103.09
(m)	Heavy Subgrade Template	1103.10



Note 1. Three-wheel rollers and tandem rollers shall weigh from 5.5 metric tons (6 tons) to 11 metric tons (12 tons) and shall have a compression on the drive wheels of not less than 35 N/mm (190 lbs. per inch) nor more than 70 N/mm (400 lbs. per inch) width of roller.

Note 2. In addition to the requirements of Article 1101.01, the tampers shall be long enough to penetrate within 25 mm (1 inch) of the prepared subgrade on the initial rolling.

Note 3. Trench rollers shall be self-propelled and shall develop a



compression of not less than 50 N/mm (300 lbs. per inch) nor more than 70 N/mm (400 lbs. per inch) of width on the compaction wheel.

Note 4. The mechanical spreader shall be self-propelled and equipped with automatic screed and grade sensing controls which control the longitudinal grade and transverse slope of the screed. Screed controls shall be such that compensation for differences from the established slope and grade will be completely automatic. The screed shall be adjustable to produce the required cross section.

Note 5. The saw shall be capable of cutting the required joints to the width and depth shown on the plans, perpendicular to the pavement surface, and without excessive spalling or raveling.

Note 6. The equipment used shall not cause marring or rutting of the subbase.

#### CONSTRUCTION REQUIREMENTS

**312.23 General.** The activator for pozzolanic stabilized mixture shall either be cement or lime at the option of the Contractor and the mixture shall be constructed between April 15 and October 15, except when lime fly ash is used, the transition date indicated in TABLE A will apply. Mixtures shall only be constructed when the air temperature in the shade is above 4 °C (40 °F.).

The Contractor shall request, in writing, specific mixture design modifications for extension of the October 15 or transition dates in Table A. Samples of ingredient materials and request for verification shall be submitted to the Central Laboratory by September 15 for cement activator and by August 15 for lime activator. Approval will be based on consideration of the cured strength development characteristics as determined by the Department's test procedure and the predicted curing degree days. The Department may extend the construction season beyond the transition dates indicated for lime fly ash mixture. In no case shall cement fly ash subbase be constructed after November 7 in the Northern Zone (Districts 1 - 4) and after November 15 in the Southern Zone (Districts 5 - 9).

The amount of pozzolanic stabilized mixture constructed shall be limited to that which can be surfaced during the current construction season. No mixture shall be deposited on a frozen or muddy roadbed. The Contractor shall assure the Department that sufficient quantities of inspected ingredient material are available to complete the work.

TABLE A TRANSITION DATES FOR POZZOLANIC STABILIZED MIXTURE		
Required Compressive Strength, MPa (14 Day Cure @ 22 °C)		
Transition Date 1/	Northern Zone <sup>2/</sup>	Southern Zone 3/
Sept. 15 Oct. 1 Oct. 15	4.8 (700) 5.8 (850) 6.5 (950)	4.5 (650) 4.8 (700) 5.8 (850)

- 1/ The transition date must be verified by samples, representing July production, submitted to the Department by August 15 for testing.
- 2/ Districts 1, 2, 3, 4.
- 3/ Districts 5, 6, 7, 8, 9.

**312.24 Composition.** The cement or lime, pozzolan, and aggregate shall be proportioned within the following approximate limits on a dry weight basis:

APPROXIMATE PERCENT BY WEIGHT OF OVEN DRY AGGREGATE		
Ingredient	Gravel, Crushed Stone, Crushed Slag or Aggregate Blend	Boiler Slag
Cement Lime Pozzolan Aggregate	3 to 5 3.5 to 6 9 to 20 74 to 88.5	3 to 6 3.5 to 6 18 to 40 54 to 79.5

The actual proportions of lime or cement, pozzolan, water and aggregate will be set by the Engineer before work begins. The actual proportions will be based on tests conducted on sample mixtures of the constituent materials furnished by the Contractor. The Department's design method will be utilized (available on request). The composition of the mixture will be such that when molded into cylinders (as prescribed in the Department's design method) and cured at 22 °C  $\pm$  1 °C (72 °F.  $\pm$  2 °F.) (14-day cure), the cylinders will have a minimum average compressive strength of 4.1 MPa (600 psi) with no individual test below 3.4 MPa (500 psi). The right is reserved by the Engineer to make changes in proportions during the progress of the work as the Engineer may consider necessary.

**312.25 Mixing.** Mixing shall be accomplished according to Article 312.16, except the control of the mixture shall be of such accuracy that the proportions of the mixture based on total dry weight will be maintained within the following tolerances:

Cement/Lime	±0.5 percent by weight
Pozzolan	±1.5 percent by weight
Aggregate	±2.0 percent by weight

If a water reducing admixture is used, the automatic dispensing system shall be capable of continuously introducing the desired quantity of admixture within the range of  $\pm 0.11$  L ( $\pm 0.03$  gal.) per minute.

When cement fly ash is constructed, mixing and spreading operations shall be coordinated such that nor more than 90 minutes shall elapse from the time water is added to the mixture and compaction operations are begun.

312.26 Placing, Compacting, and Finishing. The mixture shall be placed on subgrade meeting the requirements of Section 301. The Contractor shall have, at all times, at least 240 m (800 ft.) of subgrade prepared in advance of the subbase placement. The pozzolanic stabilized mixture shall be constructed in layers not more than 100 mm (4 inches) thick when compacted. If tests indicate that the desired results are being obtained, the compacted thickness of any layer may be increased to a maximum of 200 mm (8 inches) for lime fly ash and 300 mm (12 inches) for cement fly ash. When the thickness specified is more than maximum thickness, the mixture shall be placed in 2 or more approximately equal layers. Each layer shall be deposited full width directly on the prepared subgrade or on the preceding layer of compacted mixture with a mechanical spreader or spreader box of a type approved by the Engineer. Where the mixture must be placed in more than one layer, the previous layer shall be maintained in a moistened condition until the succeeding layer is placed. After having been tested for density and approved by the Engineer, the previous layer shall be dampened with water, if required by the Engineer. The second layer shall be placed the same day as the first layer. When placed, the pozzolanic stabilized mixture shall be free from segregation and shall require minimum blading and manipulation.

Particular care shall be exercised to ensure satisfactory density along the edges of the section and adjacent to construction joints. The type, size and number of compactors and the rate of their operation shall be such that the section being processed will be fully compacted within 3 hours of the time water is added to the mixture. The first layer of the subbase shall be compacted to at least 97 percent of maximum density. The succeeding layers of subbase shall be compacted to 100 percent of maximum density. The maximum density will be determined according to AASHTO T 180, Method C, except that the 5-lift requirement is replaced with 3 lifts.

The density of each layer of the compacted subbase will be determined by the Engineer for compliance with these Specifications according to, AASHTO T 238, Method B and AASHTO T 239, AASHTO T 191, or by other methods approved by the Engineer. If these tests indicate that the layer does not comply with the density requirements, the condition shall be corrected or the material replaced to meet these Specifications.

In constructing the top layer, the grade shall be kept at sufficient height so that the top surface, when compacted, will be at or slightly above grade, rather than below grade. Finish grading shall be accomplished by removing excess material followed by recompaction by rolling. In the event that low areas occur, they shall be reconstructed to the satisfaction of the Engineer.

If any subgrade material is worked into the pozzolanic stabilized mixture during

the compacting or finishing operations, all pozzolanic mixture within the affected area shall be removed and replaced with new material. Any finished or completed portion of the subbase which is traveled by construction equipment, or by other traffic, shall be protected in such a manner as to prevent the equipment or other traffic from marring or damaging the completed work. The Engineer may restrict hauling over partially completed work or uncured subbase after inclement weather or at any time when the subgrade is soft and there is a tendency for the subgrade material to work into the pozzolanic stabilized mixture.

When initial compaction of the mixture is nearing completion, the surface of the subbase shall be shaped to the required lines, grades, and cross section. The moisture content of the surface of the subbase mixture shall be maintained at or slightly above its specified optimum during all finishing operations and until the curing material is applied.

Surface compaction and finishing shall be done in such a manner as to produce a smooth, closely knit surface, relatively free from cracks, ridges, low spots, or loose material. The finished surface shall be tested for crown and elevation by means of a template and shall meet the tolerance in thickness requirement as stated herein.

If for any reason construction operations are delayed or suspended and the Engineer orders any loose or uncompacted material removed and disposed of, the Contractor shall perform this work at the his/her own expense. No pozzolanic stabilized mixture may be salvaged.

**312.27 Curing.** After the pozzolanic stabilized mixture has been constructed, the surface shall be kept continuously moist until the bituminous curing cover is applied. The bituminous curing cover shall be applied no later than 24 hours following final compaction unless in the judgment of the Engineer, it should be delayed. The materials and application of the curing cover shall be according to the requirements of Article 312.19 for bituminous protective cover.

Paving may proceed after the curing cover has been applied and cured to the satisfaction of the Engineer. At least 14 hours for lime fly ash and 12 hours for cement fly ash shall elapse between the time the curing cover material is applied and paving begins.

**312.28 Construction Joints and Maintenance.** At the end of each day's construction, a straight transverse construction joint shall be formed by cutting back into the completed work to form a vertical face. If the cement fly ash subbase paving operations are discontinued for more than 24 hours or when the mixture has taken a set prior to the achievement of acceptable compaction, a longitudinal and/or transverse saw joint shall be cut and the material in the affected area shall be removed and disposed of according to Article 202.03. Damage to completed work shall be avoided.

In areas where irregular width, inaccessibility, or unavoidable obstacles make the use of mechanical spreading equipment impractical, such equipment will not be required, and the Contractor may use other methods approved by the Engineer. If full-width placement is impractical, placing the adjacent pass(es) with the specified mechanical spreader to achieve the desired pavement width must be completed the same day as placement of the first pass.

The Contractor shall maintain, at his/her own expense, the entire subbase in a

manner satisfactory to the Engineer until the pavement has been completed. Maintenance shall include immediate repairs of any defective or damaged portions of the subbase. Repairs or replacements shall be made in such a manner as to ensure restoration of a uniform surface and durability of the portion repaired or replaced. The Contractor shall also remove and replace full-depth, at the Contractor's own expense, any pozzolanic aggregate mixture which is unsatisfactory due to its being placed over excessively wet or otherwise unstable subgrade; damaged by rain, freezing or other climatic conditions; damaged by traffic; or which is unsatisfactory due to failure to comply with any of the requirements specified.

#### **CEMENT AGGREGATE MIXTURE II**

**312.29 Materials.** Materials for Cement Aggregate Mixture II shall meet the requirements of the following Articles of Section 1000 - Materials.

	Item	Article/Section
(a)	Coarse Aggregate (Note 1)	1004.01-1004.02
(b)	Fine Aggregate (Note 2)	1003.01-1003.02
(c)	Portland Cement (Note 3)	1001
	Water	
(e)	Curing Materials (Note 4)	1022
	Emulsified Asphalt (Note 5)	
(g)	Concrete Admixture	1021.01-1021.04
(h)	Fly Ash	1010.03

- Note 1. Coarse aggregate shall be gradation CA-6, CA-7, CA-10 or CA-11, Class D quality or better.
- Note 2. Fine aggregate shall be FA-1 or FA-2.
- Note 3. Portland Cement Type 1 shall be used.
- Note 4. Membrane Curing Compound shall be Type III.
- Note 5. RS-1, RS-2, CRS-1 or CRS-2 shall be used.
- **312.30 Equipment.** Equipment shall meet the requirements of Article 420.03.

#### CONSTRUCTION REQUIREMENTS

**312.31 Proportioning.** At least 60 days prior to start of placing CAM II, the Contractor shall submit samples of materials for proportioning and testing. The mixture shall contain a minimum of 120 kg (200 lbs.) of portland cement per cubic meter (cubic yard), except that a maximum of 15% of cement may be replaced by fly ash at a 1:1.5 cement-to-ash ratio (weight basis). Blends of coarse and fine aggregates will be permitted, provided the volume of fine aggregate does not exceed the volume of coarse aggregate. The Engineer will determine the proportions of materials for the mixture.

Air-entraining admixture and water-reducing admixture shall be added. Water-reducing admixtures shall be added to the mixer separately from air-entraining admixtures according to the manufacturer's printed instructions. The air-entrainment agent and the other admixture(s) shall be compatible. The water and air content of

freshly mixed air-entrained CAM II shall be based upon trial mixes with the materials to be used in the work adjusted to produce a mixture of the required plasticity, workability and durability. The mixture shall have a relative durability of 80% at 100 cycles when tested according to AASHTO T 161 Procedure B. The percentage of air-entrainment shall not be less than 7 percent or more than 10 percent. Air content shall be determined according to Article 1020.08. The mix shall have a slump of 25 mm (1 inch) to 75 mm (3 inches). Slump shall be determined according to Article 1020.07.



- **312.32 Mixing and Placing.** CAM II shall be mixed according to Article 1020.11(c). No CAM II shall be deposited on a frozen or muddy subgrade or when the air temperature in the shade is less than 4 °C (40 °F.). Forms and form setting shall conform to Article 420.06 or as approved by the Engineer. The use of a mechanical form tamper will not be required. When a slipform paver will be used for placing the pcc or CRC pavement, the CAM II subbase shall be constructed to a width 150 mm (6 inches) wider than the width outside-to-outside of the slipform paver's tracks. When this results in a width greater than shown on the plans or typical section, such extended width will not be measured for payment but shall be included in the unit price bid for the CAM II subbase. Placing CAM II shall conform to the requirements of Article 420.07, except that a mechanical concrete spreader will not be required. Vibratory screeds will be permitted. Slipform paving methods may be used, provided the requirements of Article 420.17, paragraphs 1, 2, 7 and 10 are met.
- **312.33 Finishing and Testing.** After the CAM II subbase has been struck off and consolidated, and while it is still plastic, the surface including the paver trackline shall not have variations of more than 5 mm (3/16 inch) in 3 m (10 ft.) measured parallel with the centerline of pavement. Any depressions shall immediately be filled with fresh CAM II mix, struck off, consolidated and refinished. Bumps shall be cut off and the area refinished. The finished surface shall not be textured, but shall be closed.

CAM II samples shall be furnished by the Contractor and shall be taken from unconsolidated material on grade to determine the air content or slump. Testing shall be according to Article 1020.07 and 1020.08.

- **312.34 Curing.** Immediately after the finishing operations have been completed, the surface shall be cured and protected according to Articles 1020.13(a)(4), 1020.13(c) and 1101.09. All areas of membrane curing compound damaged by rain or other cause within the required three-day curing period shall be repaired by applying another coat as above. Membrane curing compound damaged after the three-day curing period shall be repaired with membrane curing compound as above or with emulsified asphalt applied at the approximate rate of 1 L/m<sup>2</sup> (0.20 gal. per sq. yd.) to the surface with a pressure distributor meeting the requirements of Article 1102.05.
- **312.35 Protection.** Minor construction traffic will not be permitted on the completed subbase for at least 3 days and no batch or haul trucks will be permitted on the completed subbase unless approved by the Engineer. The Contractor shall remove and replace at the Contractor's own expense any CAM II mixture which is unsatisfactory due to rain, freezing or other climatic conditions; damaged by traffic; or which is unsatisfactory due to failure to comply with any of the requirements specified.

#### STABILIZED SUBBASE - GENERAL

- **312.36 Tolerance in Thickness.** The subbase shall be constructed to the thickness shown on the plans. Determination for the subbase thickness will be based on thickness measurements, taken either at cored points or at the edge of the subbase. When the constructed thickness is less than 90 percent of the specified thickness, it shall be brought to the specified thickness by increasing the thickness of portland cement concrete pavement or removal and replacement with new mixture at no additional cost, except for the following:
  - (a) Bituminous Aggregate Mixture Subbase correction with additional bituminous aggregate mixture will be allowed.
  - (b) When continuously reinforced concrete pavement is to be constructed correction shall be only by removal and replacement.

The surface elevation of the completed subbase, shall not exceed by more than 5 mm (3/16 inch) the surface elevation shown on the plans or authorized by the Engineer.

#### 312.37 Method of Measurement.

- (a) Contract Quantities. The requirements for the use of Contract Quantities shall conform to Article 202.07(a).
- (b) Measured Quantities. Stabilized subbase of the thickness specified will be measured for payment in place and the area computed in square meters (square yards). The width for measurement will be from outside to outside of the top of the final layer of the completed work as shown on the plans or as directed by the Engineer. The liquid asphalt for the curing coat for either the cement aggregate mixture or pozzolanic aggregate mixture, and any sand cover required will not be measured for payment.
- **312.38 Basis of Payment.** This work will be paid for at the contract unit price per square meter (square yard) for STABILIZED SUBBASE of the thickness specified, which price shall be payment in full for the work constructed including any liquid asphalt or sand for curing coat.

#### **BASE COURSE**

#### **SECTION 350. LIME STABILIZED SOIL MIXTURE**

**350.01 Description.** This item shall consist of the construction of a lime stabilized soil mixture composed of "reactive soil", lime, and water which shall be considered as base course. The work shall be performed and measured and paid for according to the requirements of Section 310, except that the lime-soil mixture used shall provide a minimum laboratory average compressive strength of 1000 kPa (150 psi). The references in Section 310 to subbase shall be construed to include base course.

# **SECTION 351. AGGREGATE BASE COURSE**

- **351.01 Description.** The base course shall consist of furnishing and placing one or more courses of aggregate on a prepared subgrade or subbase.
- **351.02 Materials.** Materials shall meet the requirements of the following Article of Section 1000 Materials:

		Item	Article	e/Section
(a)	Aggregate			1004.04

**351.03 Equipment.** Equipment shall meet the requirements of the following Articles of Section 1100 - Equipment:

	Item	Article/Section
(a)	Tamping Roller	1101.01
(b)	Pneumatic-Tired Roller	1101.01
	Three-Wheel Roller (Note 1)	
(d)	Tandem Roller (Note 1)	1101.01
	Spreader	
	Vibratory Machine (Note 2)	



Note 1. Three-wheel or tandem rollers shall weigh from 5.5 metric tons (6 tons) to 9 metric tons (10 tons) and shall weigh not less than 35 N/mm (200 lbs. per inch) nor more than 60 N/mm (325 lbs. per inch) of width of the roller.

Note 2. The vibratory machine shall meet the approval of the Engineer.

#### CONSTRUCTION REQUIREMENTS



- **351.04 Subgrade.** The subgrade shall be prepared according to Section 301 except Articles 301.04 and 301.05 will not apply.
- **351.05** Base Course. The construction of the base course shall conform to the following requirements:
  - (a) General. The aggregate shall be uniform in gradation. Wetting the aggregate in cars, bins, stockpiles or trucks will not be permitted.

The base course shall be constructed in layers not more than 100 mm

(4 inches) thick when compacted, except that if tests indicate that the desired results are being obtained, the compacted thickness of any layer may be increased to a maximum of 200 mm (8 inches). The aggregate shall be deposited full-lane width, directly on the prepared subgrade or on the preceding layer of compacted aggregate with a spreader. When placed, it shall be free from segregation and shall require minimum blading or manipulation. Immediately after the material has been placed, it shall be compacted with a tamping roller, or with a pneumatic-tired roller, or with a vibratory machine, or with a combination of any of the three. The top layer shall be given a final rolling with a three-wheel or tandem roller. The manner of compaction shall be approved by the Engineer.

If any subgrade material is worked into the base material during the compacting or finishing operations, all granular material within the affected area shall be removed and replaced with new aggregate. The Engineer may restrict hauling over the completed or partially completed work after inclement weather or at any time when the subgrade is soft and there is a tendency for the subgrade material to work into the base material.

(b) Type A. The aggregate used for preparing Type A Base Course shall have a bearing ratio of not less than 80, except that if the aggregate used is crushed gravel, crushed stone or crushed slag, the bearing ratio will not be required.

The bearing ratio will be determined according to the Standard Methods adopted by the Department.

The Contractor shall, at his/her own expense, submit to the Engineer, a sample of the aggregate to be used for Aggregate Base Course, Type A, at least 15 days prior to starting construction. The sample so submitted will be tested by the Department for acceptance.

Before the aggregate is deposited on the subgrade, it shall contain the amount of moisture required for compaction. The amount of moisture required shall be that determined by the Engineer for the material and compaction methods being used. The water and aggregate shall be mixed at a central mixing plant. The plant shall be equipped with a mechanical mixing device, and aggregate and water measuring devices, meeting the approval of the Engineer.

The granular material shall be compacted to not less than 100 percent of the standard laboratory density. The standard laboratory density shall be the maximum density determined according to AASHTO T 99 (Method A or C). A course particle correction according to AASHTO T 224 shall be used with Method A and may be used with Method C.

The density of the compacted Base Course, Type A, will be determined by the Engineer at regular intervals according to AASHTO T 191 or AASHTO T 238 and T 239, or by other methods approved by the Engineer.

If these tests indicate that the base course does not comply with the density requirements, additional wetting, if necessary, and rolling will be required until the density is obtained. Moisture shall be added to the material during

- compaction only when it is necessary to increase the percentage of moisture to obtain the required density.
- (c) Type B. The moisture content for Type B base course shall be sufficient to prevent segregation of the aggregate. Water shall be added as required by the Engineer to obtain compaction satisfactory to the Engineer. The use of a central mixing plant to obtain moisture sufficient for compaction will be permissible.
- **351.06** Tolerance in Thickness. The base course shall be constructed to the thickness shown on the plans. Thickness determinations will be made at such points as the Engineer may select. When the constructed thickness is less than 90 percent of the specified thickness shown on the plans, aggregate shall be added to obtain the required specified thickness.
- **351.07** At Bridges, Railroad Grade Crossings and Existing Pavement. The base course adjacent to bridges, railroad grade crossings and existing pavement shall be 75 mm (3 inches) (compacted) greater in depth than the typical section, with the surface at the established grade. The width at bridges and railroad grade crossings shall be the same as the typical section. At existing pavement, the width shall be as shown on the plans or as directed by the Engineer. This 75 mm (3 inch) increase in depth shall be made at a uniform rate in a distance of 15 m (50 ft.). The cost of excavation in this transition shall be considered as included in the cost of the base course.
- **351.08** At Side Roads, Entrances and Mailboxes. The material used at side roads, entrances and mailbox turnouts shall be the same as that used to construct the base course.

After the shoulders have been completed, the subgrade shall be excavated and the bottom of the excavation shall be compacted in a manner approved by the Engineer. The earth excavated in preparing the subgrade shall be disposed of within the right of way, as directed by the Engineer, within a distance of 300 m (1000 ft.) from the place of excavation.

The excavation, preparation of subgrade and disposal of surplus excavation shall be considered as included in the cost of the base course.

- **351.09** Shaping, Trimming, Finishing and Opening to Traffic. All shaping, trimming and finishing shall conform to Section 212. The road shall be opened to traffic according to Article 701.05(b)(1).
- **351.10 Maintaining.** The Contractor shall maintain the base course until the entire section is accepted. In no case shall the maintenance period be less than 10 days for any portion of the road.

In lieu of the above specified minimum 10-day maintenance period, the Contractor, at his/her option, may elect to proof roll the completed aggregate base course. The test vehicle for proof rolling shall consist of a tandem axle truck loaded to a minimum gross weight of 18100 kg (40,000 lbs.). Proof rolling shall consist of 40 passes in each lane of the completed aggregate base course. Any failures in the base that occur during the proof rolling shall be immediately repaired and shall be subjected to an additional 5 passes of the test vehicle after the initial 40 passes are completed. This process shall be repeated, if necessary, until all failed areas pass

the proof rolling.

**351.11 Method of Measurement.** Aggregate used for base course will be measured for payment in metric tons (tons), cubic meters (cubic yards), or square meters (square yards) of the thickness specified. Aggregate used for maintenance will be measured for payment in metric tons (tons). The unit of measurement will be shown on the plans.

Water required to be added for compaction on the grade will not be measured for payment but shall be considered as included in the cost of the item of work being constructed.

The requirements for the use of contract quantities and measured quantities shall conform to Article 311.08(a) and 311.08(b), respectively.

**351.12** Basis of Payment. This work will be paid for at the contract unit price per metric ton (ton), or cubic meter (cubic yard), for AGGREGATE BASE COURSE, TYPE A, or AGGREGATE BASE COURSE, TYPE B, or at the contract unit price per square meter (square yard) for AGGREGATE BASE COURSE, TYPE A or AGGREGATE BASE COURSE, TYPE B of the thickness specified.

Additional aggregate required for maintenance will be paid for at the contract unit price per metric ton (ton) for AGGREGATE BASE COURSE, TYPE A, or AGGREGATE BASE COURSE, TYPE B.

Except as specified above for the additional aggregate required for maintenance, the work of maintaining or proof rolling the completed aggregate base will not be paid for separately, but shall be considered as included in the unit prices bid for the construction items involved, and no additional compensation will be allowed.

#### SECTION 352. SOIL-CEMENT BASE COURSE

- **352.01 Description.** This work shall consist of the construction of a soil-cement base course composed of soil, portland cement and water.
- **352.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 Materials:

Item	Article/Section
(a) Portland Cement (Notes 1 & 2)	1001
(b) Soil (Note 3)	
(c) Water	1002

- Note 1. Bulk cement may be used for travel plant method providing the equipment for handling, weighing and spreading the cement is approved by the Engineer.
- Note 2. Either Type 1 or Type 1A Portland cement shall be used.
- Note 3. The soil incorporated in the soil-cement base course shall consist of the existing soil in the roadway, imported soil, or a mixture of both, approved by the Engineer. Imported soil used in the base course shall all

pass a 37.5 mm (1 1/2-inch) sieve and shall contain not more than 15 percent retained on a 25-mm (1-inch) sieve. The base course material, whether consisting entirely of existing roadway soil, imported soil, or a mixture of both, shall all pass a 75-mm (3-inch) sieve and not more than 45 percent shall be retained on the 4.75 mm (No. 4) sieve.

**352.03 Equipment.** Equipment shall meet the requirements of the following Articles of Section 1100 - Equipment:

Item	
(a) Pressure Distributor	
(b) Pneumatic-Tired Roller	1101.01(a)
(c) Rotary Speed Mixer	1101.06
(d) Tamping Roller (Note 1)	1101.01(d)
(e) Tandem Roller (Note 2)	1101.01(e)
(f) Three-Wheel Roller (Note 2)	
(g) Traveling Mixing Plant (Note 3)	1101.07
(h) Vibratory Machine (Note 4)	

Note 1. In addition to the requirements of Article 1101.01(d), the tampers shall be long enough to penetrate within 25 mm (1 inch) of the subgrade on the initial rolling.



Note 2. Three-wheel rollers and tandem rollers shall weigh from 5.5 metric tons (6 tons) to 9 metric tons (10 tons) and shall weigh not less than 35 N/mm (200 lbs per inch) nor more than 60 N/mm (325 lbs. per inch) width of roller

Note 3. When more than 10000  $\text{m}^2$  (12,000 sq. yds.) of soil-cement base course are to be processed, a traveling mixing plant will be required together with any machine, or combination of machines, or equipment which will produce in one pass completed soil-cement base course meeting the requirements of these Specifications. Mixing devices approved by the Engineer may be used when less than 10000  $\text{m}^2$  (12,000 sq. yds.) of soil-cement base course are to be processed.

Note 4. The vibratory machine shall meet the approval of the Engineer.

**352.04** Composition, Moisture-Density Tests and Control Factors. When imported soil is used in the base course, the Contractor shall, at his/her own expense, submit to the Engineer a minimum of 10 kg (25 lbs.) of cement and 70 kg (150 lbs.) of base material which the Contractor proposes to use in the mixture. These materials shall be furnished at least 60 days prior to the construction of the soil-cement base course and will be used to determine preliminary proportion of the mixture composition. Samples of the materials shall be taken under the supervision of the Engineer.

The actual proportions of cement, water and soil material will be set by the Engineer before work begins and will be based on tests conducted on mixtures composed of constituent materials to be incorporated into the soil-cement base course. Samples of the mixture will be tested according to AASHTO T 135 and AASHTO T 136, and the maximum allowable losses as determined by either of these tests shall be as follows:

# Soil Group Classification Maximum Allowable Loss (%) A-1, A-2-4, A-2-5, A-3 14 A-2-6, A-2-7, A-4, A-5 10 A-6, A-7 7

The soil material will be classified according to AASHTO M 145. The right is reserved by the Engineer to make such changes in proportion during the progress of the work as the Engineer may consider necessary.

In addition to meeting the requirements of the above durability tests, the design mixture shall have a 7-day compressive strength of not less than the design strength specified. The design strength will be based on laboratory specimens prepared according to AASHTO T 134 which have been moist-cured for 7 days. The specimens shall be capped and soaked 4 hours immediately prior to testing.

The optimum moisture content and standard laboratory density will be determined according to AASHTO T 134.

#### **CONSTRUCTION REQUIREMENTS**

- **352.05 General.** The soil-cement base course shall be placed only when the temperature of the subgrade, measured 50 mm (2 inches) to 75 mm (3 inches) below the surface, is above 10  $^{\circ}$ C (50  $^{\circ}$ F.), and the air temperature in the shade is above 4  $^{\circ}$ C (40  $^{\circ}$ F.).
- **352.06 Preparation.** The area to be processed shall be carefully shaped to the proper grade and cross section and shall be void of all vegetation and other objectionable material.

The subsoil under the area to be processed shall be firm and capable of supporting, without displacement, the equipment used in the construction of the soil-cement base, and also other traffic, prior to acceptance of the preparation work. Any soft or unstable subsoil shall either be made stable or removed and replaced with suitable material. If the unstable subsoil is stabilized with cement, the provisions of this Specification shall apply except as modified by the Engineer. If the unstable subsoil is removed and the plans or Special Provisions do not show the method of disposal of the unstable soil, it shall be used to widen embankments, flatten slopes or be disposed of as directed by the Engineer.

- **352.07 Pulverizing.** When necessary, the soil to be processed shall be scarified and pulverized prior to the application of the cement. Pulverizing shall be continued until the soil meets the gradation requirement specified in Article 352.10 and the moisture content of the soil does not exceed that which will permit a uniform mixture of soil and cement.
- **352.08 Spreading Cement.** The quantity of cement as determined under Article 352.04 shall be uniformly spread on the soil with a mechanical spreader in a manner satisfactory to the Engineer. The spreading operations shall be limited to such an area that all the operations specified in Articles 352.08 to 352.11, inclusive, will be continuous and completed during the daylight hours; and the operations specified in Articles 352.09 to 352.11, inclusive, completed in 6 hours.

No cement shall be spread unless the soil and subgrade meet the requirements

of Articles 352.05, 352.06 and 352.07, and the percentage of moisture in the soil does not exceed the quantity which will permit a uniform mixture of soil and cement during the mixing operations.

No equipment except that used in spreading and mixing will be allowed to pass over the spread cement and this equipment shall be operated in such a manner as to avoid displacement of cement.

Cement which has been damaged by hydration due to rain prior to or during the mixing operations, which has been damaged while spread contrary to the above mentioned requirements, or which has been displaced by the Contractor's equipment or other traffic, shall be replaced by the Contractor at his/her own expense.

**352.09 Dry Mixing.** Dry mixing of soil and cement is required when mixing equipment other than a traveling mixing plant is used. After the cement is spread, it shall be mixed with the pulverized soil. No cement shall be mixed below the desired depth. Mixing shall be accomplished with mixing devices approved by the Engineer and shall be continued until the resulting mixture is homogeneous and uniform in appearance.

The mixing operations shall be confined within the lines shown on the plans and spill-over of material on the shoulders shall be avoided.

When any of the operations from the start of soil and cement mixing through final compaction are interrupted for more than 30 minutes for any reason, the entire thickness of the base course shall be thoroughly loosened, reprocessed, and shall be completed within the specified time limits for these operations. When the uncompacted soil-cement mixture is wet by rain so that the average moisture content exceeds the tolerance given in Article 352.10 at the time of final compaction, the portion being processed shall be reconstructed according to this Specification and at the expense of the Contractor.

# 352.10 Moist Mixing.

(a) With Equipment Other Than a Traveling Mixing Plant. If a traveling mixing plant is not used, water shall be immediately applied uniformly and incorporated into the dry-mixed soil and cement in quantities which will produce the required moisture content for the soil-cement mixture.

Water supply and pressure distributing equipment shall be provided which will ensure the application of all water required on the section being processed within 3 hours. Each application or increment of water shall be at least partially incorporated into the mixture if necessary to avoid excessive concentration of water on and near the surface.

After the last increment of water has been added, mixing shall be continued until a uniform mixture of soil, cement and water is obtained. Particular care shall be exercised to ensure satisfactory moisture distribution along the edges of the section and for the full depth of treatment.

When water application and moist mixing is completed, the percentage of moisture in the fraction of the mixture passing a 25 mm (1-inch) sieve, on a basis of dry weight, shall be between 80 and 100 percent of the optimum moisture content for sandy soils, and between 100 and 120 percent of the

optimum moisture content for silty and clayey soils. At completion of moist mixing, 100 percent of the soil shall pass a 25 mm (1-inch) sieve and at least 80 percent shall pass a 4.75 mm (No. 4) sieve, exclusive of gravel or stone retained on these sieves.

- (b) With a Traveling Mixing Plant. After the cement is spread, it shall be mixed with soil and water with a traveling mixing plant. No mixing shall be done below the desired depth. Mixing shall be at such rate that, or shall be repeated until, a uniform mixture of soil, cement and water is obtained. Particular care shall be exercised to ensure a satisfactory mixture along the edges of the section and for the full depth of treatment. At the completion of the mixing operation, the moisture content and gradation of the mixture shall be as specified in Article 352.10(a).
- **352.11 Compaction and Finishing.** Compacting the soil-cement mixture shall be a continuation of the moist mixing operation in such a manner that the soil-cement mixture does not remain undisturbed after mixing and before compacting for more than 30 minutes. Prior to the beginning of compaction, the mixture shall be in a loose condition for its full depth and width. The mixture shall then be uniformly compacted with tamping rollers in conjunction with other compaction equipment until the specified density has been obtained. Particular care shall be exercised to ensure satisfactory density along the edges of the section and adjacent to construction joints. The type, size, and number of compactors, and the rate of their operation, shall be such that the section being processed can be compacted within 2 hours.

When initial compaction of the soil-cement mixture is nearing completion, the surface of the base course shall be shaped to the required lines, grades and cross section, and compaction continued until uniform and adequate compaction is obtained. If necessary to attain satisfactory surface grade, the surface shall be lightly scarified with a nail drag, spike-tooth harrow or weeder, and reshaped. The resulting surface then shall be thoroughly rolled with a three-wheel or tandem roller, or a pneumatic-tired roller, or both, of the size and type specified in Article 352.03, Equipment, and meeting the needs of the work. The moisture content of the surface material shall be maintained at or slightly above its specified optimum during all finishing operations and until the curing material is applied.

Surface compaction and finishing shall be done in such a manner as to produce a smooth, closely knit surface, relatively free from cracks, ridges, low spots, or loose material, conforming to the crown, grades, and lines shown on the plans. When directed by the Engineer, surface finishing methods may be varied provided a smooth, dense, uniform surface, free of surface compaction planes, is produced.

The density of the soil-cement base course will be determined by the Engineer near the end of the finishing operations. Any portion of the base course that has a density less than 95 percent of the standard laboratory density or which is 13 mm (1/2-inch) thicker or thinner than the required thickness, shall be corrected or removed and replaced to meet this Specification. The standard laboratory density for field control of mixed-in-place soil-cement will be determined from samples of the field mixture, prior to compaction, according to AASHTO T 99, Method A. The standard laboratory density of soil-cement mixtures produced at a central plant will be determined according to AASHTO T 134, Method A or B. The following modifications are applicable:

All standard laboratory densities will be adjusted to compensate for differing

percentages of particles retained on the 4.75 mm (No. 4) sieve according to AASHTO T 224.

A standard laboratory density will be obtained for each in-place compaction test of field-mixed mixture.

The drying apparatus for moisture determination for field control will consist of a stove, oven or other suitable equipment.

The density of the compacted soil-cement base course will be determined by the Engineer at regular intervals according to AASHTO T 191 or AASHTO T 238 and T 239, or by other methods approved by the Engineer.

The completed and cured base course will be tested for soundness by the Engineer by dropping a mattock handle from a perpendicular position. Any portion of the base course which does not produce a solid ring when so tested, or which does not produce a good rebound of the mattock handle will be further investigated. Any correction or replacement directed by the Engineer according to this Article shall be considered as included in the cost of the work and will not be paid for directly.

- **352.12 Protection and Cover.** After the soil-cement base course has been finished as specified herein, it shall be protected against drying for a period of 7 days by applying a bituminous material according to the requirements of Article 312.19 except that the bituminous material shall be applied as soon as possible after the completion of finishing operations, but in no event shall the finished soil-cement base course remain without cover for more than 14 hours unless prolonged rain intervenes. The reference in Article 312.19 to cement aggregate mixture and to subbase shall be construed to include soil-cement base course and base course, respectively.
- **352.13 Construction Joints.** At the end of each day's construction, a straight transverse construction joint shall be formed by cutting back into the completed work to form a vertical face. Damage to completed work shall be avoided. The base course shall be constructed and finished full width each day without longitudinal joints.
- **352.14 Opening to Traffic.** The road shall be opened to traffic according to Article 701.05(b)(2).
- **352.15 Maintenance.** The Contractor shall maintain, at his/her own expense, the entire base course in a manner satisfactory to the Engineer until the surface course has been constructed. Maintenance shall include immediate repairs of any defective or damaged portions of the base course. Repairs or replacements shall be made in such a manner as to ensure restoration of a uniform surface and durability of the portion repaired or replaced.

The Contractor shall also remove and replace, at his/her own expense, any soil-cement base course which is unsatisfactory due to its being placed over excessively wet or otherwise unstable subgrade; damaged by rain, freezing or other climatic conditions; damaged by traffic; or which is unsatisfactory due to failure to comply with any of the requirements specified.

**352.16 Tolerance in Thickness.** Soil-cement base course shall be constructed to the thickness shown on the plans. Determination of base thickness will be based on thickness measurements at cored points taken at locations selected by the Engineer. Any portion of the soil-cement base course that is less than 90

percent of the specified thickness shall be removed and replaced with new material to the correct thickness by the Contractor at his/her own expense.

#### 352.17 Method of Measurement.

- (a) Contract Quantities. The requirements for the use of Contract Quantities shall conform to Article 202.07(a).
- (b) Measure Quantities. The work shall be measured for payment according to the following methods:
  - (1) Processing of soil-cement base course will be measured for payment in place and the area computed in square meters (square yards) of soil-cement base course completed and accepted.
  - (2) Cement incorporated in the soil-cement mixture will be measured for payment in kilograms (hundredweights), but payment will not be made for cement in excess of 105 percent of the amount specified by the Engineer.
  - (3) Removal and disposal of unstable or unsuitable subsoil will be measured for payment as Earth Excavation as specified in Article 202.07(b).
  - (4) Replacement of unstable or unsuitable subsoil will be measured for payment as Embankment as specified in Article 205.09(b).
  - (5) Cement treatment of unstable subsoil, if required by the Engineer, will be measured for payment according to (1) and (2) above.
  - (6) Water used for mixing, compacting and finishing will not be measured for payment, but shall be considered as included in the cost of Processing Soil-Cement Base Course.
  - (7) Any materials used or required for protection and cover will not be measured for payment but shall be considered as included in the cost of Processing Soil-Cement Base Course.
- **352.18 Basis of Payment.** This work will be paid for at the contract unit prices as follows:
  - (a) Per square meter (square yard) for PROCESSING SOIL-CEMENT BASE COURSE.
  - (b) Per kilogram (hundredweight) for CEMENT.
  - (c) Per cubic meter (cubic yard) for EARTH EXCAVATION for the removal and disposal of unstable or unsuitable subsoil.
  - (d) Per cubic meter (cubic yard) for EMBANKMENT for the replacement of unstable or unsuitable subsoil.
  - (e) Cement treatment of unstable subgrade soil, when specified by the Engineer, will be paid for at the contract unit prices for (a) and (b) above.

# Portland Cement Concrete Base Course



# SECTION 353. PORTLAND CEMENT CONCRETE BASE COURSE

- **353.01 Description.** This work shall consist of constructing a portland cement concrete base with or without reinforcement as specified.
- **353.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 Materials:

	Item	Article/Section
(a)	Portland Cement Concrete	1020
(b)	Reinforcement Bars	1006.10
(c)	Longitudinal Metal Joints, Pins, Bar Supports	1006.11

**353.03 Equipment.** Equipment shall meet the requirements of the following Articles of Section 1100 - Equipment:

Item	Article/Section
(a) Forms	
	1103.16
(c) Form Grader	
(d) Water Supply Equipment	1103.11
(e) Batching and Weighing Equipmer	it 1103.02-1103.03
(f) Concrete Mixers	1103.01
(g) Truck Agitator	1103.01
(h) Nonagitator Truck	1103.01
(i) Heavy Subgrade Template	1103.10
	1103.08
(k) Subgrade Machine	1103.09
	1103.13
(m) Mechanical Longitudinal Float or	Concrete Finisher Float . 1103.14-1103.15
(n) Vibrator	1103.12, 1103.17
(o) Miscellaneous Equipment	
(p) Membrane Curing Equipment	1101.09

#### CONSTRUCTION REQUIREMENTS

**353.04 General.** The use of slip form paving will be permitted at the option of the Contractor. If the Contractor cannot obtain satisfactory results without the use of forms, the Department reserves the right to require the use of forms without additional compensation to the Contractor.

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## Portland Cement Concrete Base Course

These items of work shall meet the following requirements:

	Item	Article/Section
(a)	Preparation of Subgrade or Subbase	420.05
(b)	Joints	420.10
(c)	Removing Forms	420.13
(d)	Protection of Pavement	420.15
(e)	Concrete Pavement-Slip Form Method	420.17
(f)	Temperature Control for Placement	1020.14
(g)	Tolerance in Thickness	420.18
(h)	Bridge Approach Pavement	
(i)	Opening to Traffic (Note 1)	701.05(c)(6)

Note 1. The references in Article 701.05(c)(6) to portland cement concrete pavement shall be construed to include portland cement concrete base course.

- **353.05** Forms and Form Setting. Forms and form setting shall conform to the requirements of Article 420.06, except that the use of mechanical form tamper will not be required.
- **353.06 Placing Concrete.** Placing concrete shall conform to the requirements of Article 420.07, except that a mechanical concrete spreader will not be required. When the base course is to be struck off and consolidated by either the vibrating screed method or the hand method, the concrete adjacent to both side forms shall be compacted with a vibrator inserted into the concrete and worked along the entire length of the forms before the finishing operations are started.

Transit mixers or trucks will be permitted on the finished subgrade or subbase when permitted by the Engineer. Approval will be withdrawn if rutting develops in the subgrade or subbase which would reduce the plan thickness of the base course.

- **353.07 Transverse Construction Joints.** Transverse construction joints shall be constructed according to Article 420.10(g) except that No. 20 (No. 6) tie bars 900 mm (36 inches) long shall be centered across the joint on 375-mm (15-inch) spacings.
- **353.08** Adjacent to Railroad Grade Crossing. PCC base course adjacent to railroad grade crossing shall be constructed according to Article 420.20 except that when the main line pcc base course thickness is greater than 225 mm (9 inches), the thickness of the pcc base course adjacent to the railroad grade crossing shall be constructed to the same thickness as the main line.
- **353.09** Adjacent to Bridge Approach Pavement or Existing Pavement. The bituminous plug adjacent to bridge approach pavement or existing pavement shall be constructed of bituminous concrete binder course mixture according to the applicable requirements of Section 406. At the Contractor's option, Class I bituminous concrete surface mixture may be used in lieu of the binder course mixture.
- **353.10** Final Strike Off, Consolidation and Finishing. The concrete shall be struck off, consolidated and finished according to Article 420.11, except the straightedging specified under Article 420.11(c) shall be performed until the entire surface does not vary more than 5 mm (3/16 inch) from the straightedge and the final

## Portland Cement Concrete Base Course

finish shall be according to Article 420.11(e), Type B.

**353.11 Surface Test.** The finished surface of the base course shall be within the tolerance of the following surface trueness test:

The base course will be tested for trueness in each wheel lane at the expiration of the required curing or protection period. The surface will be tested by means of a 5-m (16-ft.) straightedge placed parallel to the centerline of the base course, parallel to the grade line and touching the surface. Surface variations which exceeds 10 mm (3/8 inch) will be marked and shall be removed by an approved grinding device consisting of multiple saws. The use of a bushhammer or other impact devices will not be permitted. Determination of base course thickness will be made after the removal of high spots.

#### 353.12 Method of Measurement.

- (a) Contract Quantities. The requirements for the use of contract quantities shall conform to Article 202.07(a).
- (b) Measured Quantities. Portland cement concrete base course will be measured in place and the area computed in square meters (square yards). The width shall be as shown on the plans or as directed by the Engineer.

Reinforcement bars will be measured in kilograms (pounds) according to Article 508.07.

**353.13 Basis of Payment.** This work will be paid for at the contract unit prices per square meter (square yard) for PORTLAND CEMENT CONCRETE BASE COURSE and HIGH-EARLY STRENGTH PORTLAND CEMENT CONCRETE BASE COURSE, of the thickness specified.

Reinforcement bars in special concrete slabs will be paid for according to Section 508.

The unit prices bid for the various items of pc concrete base course shall include any added thickness of base course adjacent to railroad grade crossings.



The bituminous plug at railroad grade crossing, bridge approach pavement or existing pavement will be paid for at the contract unit price per metric ton (ton) for BITUMINOUS CONCRETE BINDER COURSE, CLASS I, TYPE 2, as specified in Section 406.

# SECTION 354. PORTLAND CEMENT CONCRETE BASE COURSE WIDENING

**354.01 Description.** This work shall consist of widening existing pavement with a portland cement concrete base course widening not exceeding 1.8 m (6 ft.) in width.

**354.02 Materials.** Materials shall meet the requirements of the following Article of Section 1000 - Materials:

	Item	Article/Se	ection
(a)	Portland Cement Concrete		1020

**354.03 Equipment.** Equipment shall meet the requirements of the following Articles of Section 1100 - Equipment:

	Item	Article/Section
(a)	Forms	
(b)	Water Supply Equipment	1103.11
(c)		1103.02-1103.03
(d)	Concrete Mixers	1103.01
(e)	Truck Agitator	1103.01
(f)		1103.01
(g)	Finishing Machine	1103.13
(h)	Vibrator	1103.12, 1103.17
(i)	Miscellaneous Equipment	
(j)	Membrane Curing Equipment	1101.09(c)

Note 1. The requirement for special bodies for nonagitating trucks shall not apply.

#### **CONSTRUCTION REQUIREMENTS**

**354.04 General.** The methods used in performing the following items of work shall meet the requirements shown in the Articles listed below. The use of slip form methods for base course widening will be permitted at the option of the Contractor.

	Item	Article/Section
(a)	Removing Forms	420.13
(b)	Temperature Control for Placement	1020.14
(c)	Opening and Keeping Road	
` '	Open to Traffic (Note 1)	701.05(c)(6)

Note 1. The reference in Article 701.05(c)(6) to portland cement concrete pavement shall be construed to include portland cement concrete base course widening.

**354.05 Subgrade.** The subgrade shall be prepared according to Article 420.05 except as follows:

- (a) The subgrade excavation shall be to the required depth for at least the full width of the proposed base course widening prior to placing the concrete. Excavation of the subgrade shall be as specified in Article 202.06.
- (b) The subgrade shall be rolled with a roller of a type approved by the Engineer. It shall be not less than 300 mm (12 inches) in width and shall weigh from 9 N/mm (50 lbs. per inch) to 18 N/mm (100 lbs. per inch) of width of the roller.

- (c) Transit mixers or trucks will be permitted on the finished subgrade when approved by the Engineer. Approval will be withdrawn if rutting develops in the subgrade or subbase which reduces the plan thickness of the base course.
- **354.06 Constructing Without Forms.** If the base course widening is constructed without forms, the following requirements shall apply:
  - (a) The concrete shall be placed on the subgrade in a manner which will not cause segregation and which will meet the approval of the Engineer. It shall be struck off to the required elevation and properly consolidated. Consolidation shall be obtained by the use of internal vibration and by a mechanical surface vibrator or tamper, or one or more oscillating screeds. After the concrete has been consolidated, the surface of the concrete shall be finished by means of a metal plate. The plate shall be the full width of the widening and shall have a length of not less than 1 m (3 ft.). The plate shall exert sufficient pressure on the concrete to produce a smooth and even surface.
  - (b) The outer edge of the base course widening shall be supported for its full depth during the placing, consolidating and finishing of the concrete by a vertical slip form and thereafter by earth banked against the edge, except that if the consistency and consolidation of the concrete and the equipment and method used are such that the concrete will retain its form satisfactorily, the earth support may be omitted.
  - (c) The device used to construct the base course widening shall be guided by the edge of the existing pavement, and it shall ride exclusively on the existing pavement.
- **354.07 Constructing With Forms.** If the base course widening is constructed with forms, the following requirements shall apply:
  - (a) Forms and Form Setting. Forms and form setting shall conform to the requirements of Article 420.06, except a mechanical form tamper will not be required.
  - (b) Placing Concrete. Concrete shall be placed according to Article 420.07, except that a mechanical concrete spreader will not be required. Spreading with shovels will be permitted. The base course widening may be struck off and consolidated by any of the 3 methods listed in Article 420.11(a). The concrete adjacent to the side form and the existing pavement shall be compacted with a vibrator inserted into the concrete and worked along the entire length of the side form and the existing pavement before the finishing operations are started.
  - (c) Final Strike Off and Finishing. The concrete shall be finished to an even and uniform surface by the use of hand floats or other approved methods.
- **354.08 Curing and Protection.** The base course widening shall be cured and protected according to the applicable paragraphs of Article 1020.13. The total amount of membrane curing compound may be applied in one application of 1 L/3 m<sup>2</sup> (1 gal. per 125 sq. ft.) instead of 2 applications, providing satisfactory

coverage is obtained.

- **354.09 Tolerance in Thickness.** The concrete base course widening shall be constructed to the thickness shown on the plans. Determination of concrete base course thickness and requirements relative to deficient thickness shall be as provided in Article 407.10, except as follows:
  - (a) The width of a unit shall be the width of the concrete base course widening along one edge of the existing pavement.
  - (b) Edge thickness may be measured instead of measuring the thickness at cored points. If edge thickness measurements are used, it shall be understood that references to cores and thickness at cored points will be applicable; and that the thickness of a unit will be determined in the same manner as would be done if the thickness had been measured at cored points.
- **354.10 Backfill at Edge.** Within 24 hours after completion of the base course widening, the remaining portion of the widening trench shall be backfilled as specified in Article 202.06. Prior to opening the base course widening to traffic, the Contractor shall compact the earth backfill adjacent to the base course. Compaction shall be obtained with a pneumatic-tired roller, to the satisfaction of the Engineer.
- **354.11 Earth Shoulders.** At locations where no provisions have been made for the repair or improvement of the earth shoulders, they shall be left in as good a condition as they were before work was started. Such work as the Contractor may have to perform to meet this requirement shall be done at no extra cost to the Department.
- **354.12 Method of Measurement.** Portland cement concrete base course widening will be measured for payment according to Article 353.12.
- **354.13 Basis of Payment.** Where the Department requires that portland cement concrete be used, this work will be paid for at the contract unit price per square meter (square yard) for PORTLAND CEMENT CONCRETE BASE COURSE WIDENING and HIGH- EARLY-STRENGTH PORTLAND CEMENT CONCRETE BASE COURSE WIDENING, each of the thickness specified.

When the Contractor has the option of using either portland cement concrete or bituminous concrete according to Section 356, the work will be paid for at the contract unit price per square meter (square yard) for BASE COURSE WIDENING, of the thickness specified.

#### SECTION 355. BITUMINOUS BASE COURSE

- **355.01 Description.** This item shall consist of constructing bituminous base course on a prepared subgrade.
- **355.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 Materials:

	Item	Article/Section
(a)	Coarse Aggregate (Note 1)	1004.01
(b)	Fine Aggregate (Note 1)	1003.01
		1011
(e)	Bituminous Material (Note 2)	

Note 1. The coarse aggregate shall be crushed stone or crushed gravel CA-6 or CA-10. After processing through the plant, the aggregate(s) shall contain at least 3 percent minus 75  $\mu m$  (No. 200) sieve material as determined by an unwashed sample of the combined hot bin proportions. When approved by the Engineer, crushed gravel or crushed stone, as described in Article 1004.01(a), may be blended with not more than 50 percent fine aggregate (passing the 4.75 mm (No. 4) sieve), as described in Article 1003.03(a), and/or mineral filler to meet the CA-6 or CA-10 gradation. The percent of fine aggregate in the blend will be based on the cold feed proportions. Blending proportions shall not be changed during the progress of the work without permission from the Engineer. The coarse aggregate shall be Class C quality or better. When used, fine aggregate shall be Class C quality or better.



Note 2. The bituminous material used for this work shall be one of the following grades of asphalt cements: AC-10 or AC-20. When the pavement has a structural number (Dt) of 3.00 or less, AC-5 or AC-10 shall be used. When RAP material is used, AC-2.5, AC-5 or AC-10 shall be used. The Engineer reserves the right to specify the grade which shall be used. The bituminous material shall not be changed during the progress of the work without permission from the Engineer.

**355.03 Equipment.** Equipment shall meet the requirements of the following Articles of Section 1100 - Equipment:

	Item	Article/Section
(a)	Self-Propelled Pneumatic-Tired Roller (Note 1)	1101.01
(b)	Three-Wheel Roller (Note 2)	1101.01
(c)	Vibratory Roller	1101.01
(d)	Tandem Roller (Note 3)	1101.01
(e)	Hot-Mix Plant (Note 4)	
(f)	Spreading and Finishing Machine (Note 5)	1102.03
(g)	Pressure Distributor	1102.05
(h)	Heating Equipment	1102.07
(i)	Trench Roller	1101.01
(j)	Hot-Mix Surge Bins	1102.01



Note 1. The self-propelled pneumatic-tired roller shall develop a compression of not less than 55 N/mm (300 lbs. per inch) nor more than 85 N/mm (500 lbs. per inch) of width of tire tread in contact with the bituminous surface. The tires shall be inflated to an air pressure of not less than 550 kPa (80 psi).

Note 2. The three-wheel roller shall have a mass (weight) of 5.5 to 9 metric tons (6 to 10 tons) and shall have a unit compression on the drive wheels of not less than 55 N/mm (300 lbs. per inch) nor more

than 70 N/mm (400 lbs. per inch) of roller width.

- Note 3. The tandem roller shall have a mass (weight) of 7 to 11 metric tons (8 to 12 tons) and shall have a unit compression on the drive wheels of not less than 45 N/mm (250 lbs. per inch) nor more than 70 N/mm (400 lbs. per inch) of roller width.
- Note 4. A hot-mix plant conforming to Article 1102.01 will be required except that Articles 1102.01(a)(5), (8), and (9), 1102.01(b)(2) and (7), 1102.01(c)(1) and (5), and the requirements of a metering system for the collected dust will not apply. When aggregates are blended, aggregate feeders for each size shall be provided according to Article 1102.01(a)(5). If mineral filler is used, Article 1102.01(b)(2) shall also apply. When a drier-drum hot-mix plant is used to produce bituminous base course incorporating RAP material, the plant shall be suitably modified to produce recycled bituminous mixes in a manner approved by the Engineer.
- Note 5. In addition to the requirements of Article 1102.03, the screed of the spreading and finishing machine shall be supported. The supporting device shall have points of bearing not less than 4.5 meters (15 ft.) apart. The screed shall be adjustable and located midway between the bearing points. The back bearing points shall be smooth, steel wheels not less than 500 mm (20 inches) wide having a diameter of not less than 750 mm (30 inches) and shall ride on the surface of the mixture being placed. A suitable means shall be provided to lock the adjustment screws in place. The leveling device shall be effective in leveling depressions in the subgrade, subbase or the existing pavement, the leveling course and the binder course. The leveling device shall meet the approval of the Engineer and shall be used for all courses being placed. An automatic grade control device meeting the approval of the Engineer may be used in lieu of above leveling device.

#### CONSTRUCTION REQUIREMENTS

- **355.04 General.** The bituminous base course mixture shall be constructed on a dry, unfrozen subgrade prepared according to the requirements of Section 301 except Articles 301.04 and 301.05 will not apply, or Section 302 when specified.
- **355.05 Composition of the Mixture.** The aggregate and bitumen shall be proportioned within the following approximate composition limits by weight:

<u>Ingredient</u>	Percent by Dry Weight
,	93.0 to 96.0 4.0 to 7.0

When RAP materials are being used, the RAP material, virgin aggregate(s) and asphalt cement shall be proportioned within the following composition limits by weight:



<u>Ingredient</u>	Percent by Dry Weight
Virgin Aggregate(s)RAP Material(s)	
Mineral Filler (if required)	
Asphalt Cement	4.0-7.0

When required by the Engineer, the Contractor shall submit a sample of the aggregate(s) and asphalt, at least 4 weeks prior to the start of production, to the Central Laboratory in Springfield for mix design purposes. The percentage of bitumen will be set by the Engineer. The asphalt content and the aggregate gradation requirement will be verified by the extraction of the final mixture. The asphalt content shall not vary more than ±0.5 percent from the bitumen content set by the Engineer.

Bituminous Concrete Binder Course Mixture A or B meeting the requirements specified in Article 406.13 will also be permitted.

355.06 Preparation. The asphalt cement shall be transferred to the asphalt tanks and heated to a temperature of 120 °C (250 °F.) to 175 °C (350 °F.). If the loading temperature exceeds 175 °C (350 °F.), the asphalt shall not be used until it has cooled to 175 °C (350 °F.). Wide variations in temperature which affect the amount of asphalt delivered will not be permitted.

When a hot-mix plant conforming to Article 1102.01 is used, the aggregate shall be dried and heated in the revolving drier to a temperature of 120 °C (250 °F.) to 175 °C (350 °F.).

The aggregate and bituminous material used shall be measured separately and accurately by weight or by volume. When the aggregate is in the mixer, the bituminous material shall be added and mixing continued until a homogeneous mixture is produced in which all particles of the aggregate are coated. The mixing period, size of the batch, or the production rate of continuous mixers will be established by the Engineer. A minimum of 30 seconds mixing time will be required for all types of plants.

The ingredients shall be heated and combined in such a manner as to produce a mixture which when discharged from the mixer will, in general, vary not more than 10 °C (20 °F.) from the production temperature set by the Engineer. temperature of the mixture shall not be more than 175 °C (350 °F.). The mixture shall be delivered at a temperature of 110 °C (225 °F.) to 175 °C (350 °F.).

When RAP material(s) is used in the bituminous base course, the virgin aggregate(s) shall be dried and heated in the drier to a temperature that will produce the specified resultant mix temperature when combined with the RAP material.

The heated virgin aggregates and mineral filler shall be combined with the RAP material in such a manner as to produce a bituminous mixture which when discharged from the mixer shall not vary more than 15 °C (30 °F.) from the temperature set by the Engineer. The combined ingredients shall be mixed for a minimum of 30 seconds or until a homogeneous mixture as to composition and temperature is obtained. For a batch type plant, the standard 15 seconds dry and 30 seconds wet mixing time should normally be used. Variation in wet and dry mixing times may be permitted, depending on the moisture content and amount of salvaged material used. The mix temperature shall not exceed 175 °C (350 °F.). Wide variations in the mixture temperature will be cause for rejection of the mix.

The final mixture(s) shall conform to the following Standard Deviations. These deviations will be verified by extraction tests of the final mixture. If these stipulations are not met, the amount of RAP material used shall be reduced by 10 percent increments per day until mix is produced meeting these requirements. When the Contractor is able to produce mixtures within these criteria for 3 consecutive days, the percent of RAP material may again be increased.

Selected Criteria (CA-6)	Standard Deviation 1/	Tolerance 2/
Passing 25 mm (1-inch) sieve Passing 12.5 mm (1/2-inch) sieve	5.0 6.5	90-100 60- 90
Passing 4.75 mm (No. 4) sieve	5.5	30- 56
Passing 1.18 mm (No. 16) sieve	4.5	10- 40
Passing 75 μm (No. 200) sieve	2.5	4- 12
Bitumen	0.5	3- 7
Selected Criteria (CA-10)	Standard Deviation 1/	Tolerance 2/
Selected Criteria (CA-10)  Passing 25 mm (1 inch) sieve	Standard Deviation 1/	Tolerance 2/
	Standard Deviation 1/ 6.5	
Passing 25 mm (1 inch) sieve		100
Passing 25 mm (1 inch) sieve Passing 12.5 mm (1/2 inch) sieve	 6.5	100 65- 95
Passing 25 mm (1 inch) sieve Passing 12.5 mm (1/2 inch) sieve Passing 4.75 mm (No. 4) sieve	6.5 6.0	100 65- 95 40- 60

- 1/ Represents the Standard Deviation of the overall population. 2/ Individual tests shall be between these tolerances.
- **355.07 Transportation.** Transportation of the mixture shall be according to Article 406.14.
- **355.08 Placing.** The bituminous mixture shall be delivered at the required temperature and placed to the required grade with a spreading and finishing machine. The thickness of each lift shall not exceed a maximum of 100 mm (4 inches) thick when compacted, except the top lift shall be a nominal 50-mm (2-inch) thick compacted layer. If the Contractor elects to substitute an approved vibratory roller for one of the required rollers to compact the mix, the compacted lift thickness on the lower lifts may be increased to 150 mm (6 inches), provided the required density is obtained. The surface of each layer shall be clean and dry before succeeding layers are placed.
- **355.09 Compaction.** Immediately after the bituminous mixture is placed, it shall be given an initial rolling with a three-wheel roller, pneumatic-tired roller, tandem roller or a vibratory roller. After the initial rolling, the base course shall be given a final or finish rolling with a tandem roller.

When initial rolling causes undue displacement, hair-cracking or checking in the base course, the time of rolling will be adjusted by the Engineer to correct these conditions.

The base course shall be compacted to a density of not less than 93 percent of the maximum theoretical density. The theoretical density will be determined by the high pressure air meter or according to ASTM D 2041.

The density of each of the finished lifts of bituminous mixture shall be obtained from nuclear test methods or from specimens furnished by the Contractor as provided in Article 406.16.

- **355.10 Surface Test.** The finished surface of the base course shall be within the tolerance of the following surface trueness test. The completed base course will be tested for trueness in each wheel lane by means of a 5-m (16-ft.) straightedge placed parallel to the centerline of the pavement, parallel to the grade line and touching the surface. Surface variations of the base measured from the base of the straightedge to the surface of the pavement shall not exceed 10 mm (3/8 inch). Areas which have variations exceeding 10 mm (3/8 inch) in 5 m (16 ft.) shall be corrected as directed by the Engineer.
- **355.11 Tolerance in Thickness.** The base course shall be constructed to the thickness shown on the plans. Determination of the base course thickness will be based on thickness measurements, taken either at cored points or at the edge of the base. Computation of thickness and penalties relative to deficient thickness shall be as provided in Article 407.10.
- **355.12 Method of Measurement.** Bituminous base course will be measured for payment according to the requirements of Article 353.12. The reference in Article 353.12 to portland cement concrete base course shall be construed to include bituminous base course.
- **355.13** Basis of Payment. This work will be paid for at the contract unit price per square meter (square yard) for BITUMINOUS BASE COURSE, of the thickness specified.

# SECTION 356. BITUMINOUS CONCRETE BASE COURSE WIDENING

- **356.01 Description.** This work shall consist of widening existing pavement with a base course consisting of bituminous concrete. The width of the base course is not to exceed 1.8 m (6 ft.).
- **356.02 Materials.** The materials for the bituminous concrete mixture shall meet the requirements specified in Article 406.02 or Article 355.02.
- **356.03 Equipment.** Equipment used in the construction of this work shall meet the requirements of Article 406.03 or Article 355.03, except that a mechanical spreader meeting the approval of the Engineer shall be used to place the bituminous concrete mixture.

If the Contractor elects to use a vibratory roller for compacting the bituminous concrete mixture, it shall meet the approval of the Engineer.

#### **CONSTRUCTION REQUIREMENTS**

**356.04** Keeping Road Open to Traffic. The road shall be kept open according to Article 701.04(b)(1).

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**356.05 Subgrade.** The subgrade shall be prepared according to Section 301 except Articles 301.04 and 301.05 will not apply. The following shall also apply:

The material adjacent to the edge of the existing pavement shall be excavated for the full bottom width required and to the required depth. The method used to excavate the subgrade shall be as specified in Article 202.06. After the excavation has been completed, the subgrade shall be compacted by rolling according to Article 354.05(b).

**356.06** Base Course Widening. The bituminous concrete mixture used to construct the base course widening shall be Binder Mixture A or B, meeting the requirements specified in Articles 406.10 and 406.12 and shall be transported according to Article 406.14, or it may be Bituminous Base Course Material meeting the requirements of Section 355.

After the subgrade has been compacted and is acceptable to the Engineer, the bituminous concrete mixture shall be spread upon it with a mechanical spreader.

Prior to placing the bituminous concrete mixture, the exposed edge of all existing pavement shall be cleaned of loose material to the satisfaction of the Engineer. This work shall be considered as included in the cost of Bituminous Concrete Base Course Widening.

Immediately after the mixture has been spread, it shall be rolled. Two rollers will be required. Rollers shall be operated at a speed of not more than 45 m (150 ft.) per minute. If the Contractor elects to use a vibratory roller for compacting the bituminous concrete mixture, the initial rolling of each layer shall be made with a nonvibratory roller.

The bituminous concrete mixture shall be placed in 2 or more layers. The top or final layer shall not be less than 50 mm (2 inches) in compacted thickness.

Each layer of bituminous concrete mixture shall be compacted to a density of not less than 93 percent of the maximum possible density of a voidless mixture composed of the same materials in like proportions. If the required density cannot be obtained when the bituminous concrete mixture is spread and compacted in 2 layers, the mixture shall be spread and compacted so as to provide 3 equal, compacted layers. If the required density cannot be obtained when the bituminous concrete mixture is spread and compacted in 3 layers with 2 rollers, an additional roller will be required. No additional compensation will be allowed the Contractor should the Contractor be required to construct the widening in 3 layers or provide an additional roller.

Only one layer of bituminous concrete mixture shall be placed in a day's run regardless of its thickness, unless otherwise authorized by the Engineer.

While compacting the top layer of the bituminous concrete mixture, care shall be exercised to keep the roller off the edge of the existing pavement so that the entire weight of the roller will be upon the mixture being compacted.

The density of each compacted layer will be obtained by approved nuclear methods or from specimens furnished by the Contractor. Specimens shall be cut by the Contractor from each compacted layer with a core drill. The diameter of a specimen shall be no less than 90 mm (3 5/8 inches). Two specimens shall be taken from each day's run not later than the morning of the first work day following the

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previous placement. When directed by the Engineer, additional specimens shall be taken but the total number from one day's run will not exceed 10. The Contractor shall remove the specimens at locations designated by and in the presence of the Engineer and transport them to the plant laboratory. Care shall be exercised to avoid damage to the specimens. The holes caused by the removal of the specimens shall be refilled immediately with a bituminous mixture meeting these specifications, compacted, and finished to the satisfaction of the Engineer. The cost of this work will not be paid for separately, but shall be included in the unit price bid per square meter (square yard) for Bituminous Concrete Base Course Widening.

- **356.07 Tolerance in Thickness.** Determination of bituminous base course widening thickness and requirements relative to deficient thickness will be according to Article 354.09.
- **356.08** Backfill at Edge of Widening. Backfilling at edge of widening shall be performed as specified in Article 354.10.
- **356.09 Earth Shoulders.** Earth shoulders shall be constructed according to Article 354.11.
- **356.10 Method of Measurement.** Bituminous concrete base course widening will be measured for payment according to the requirements of Article 353.12. The reference in Article 353.12 to portland cement concrete base course shall be construed to include bituminous concrete base course widening.
- **356.11 Basis of Payment.** Where the Department requires that Bituminous Concrete be used, this work will be paid for at the contract unit price per square meter (square yard) for BITUMINOUS CONCRETE BASE COURSE WIDENING, of the thickness specified.

When the Contractor has the option of using either portland cement concrete as outlined in Section 354 or bituminous concrete according to Section 356, the work will be paid for at the contract unit price per square meter (square yard) for BASE COURSE WIDENING, of the thickness specified.

#### SECTION 357. POZZOLANIC STABILIZED BASE COURSE

- **357.01 Description.** This work shall consist of constructing Pozzolanic Stabilized Base Course.
- **357.02 Materials.** Materials shall meet the requirements of Article 312.21 with the following addition:

- **357.03 Equipment.** Equipment shall meet the requirements of Article 312.22 with the following addition:
  - (a) Heating Equipment for Joint Sealant (Note 7)

Note 7. The heating equipment shall be of an indirect heating type with positive temperature control, mechanical agitation and recirculating pump.

#### **CONSTRUCTION REQUIREMENTS**

**357.04 General.** The requirements for constructing Pozzolanic Stabilized Base Course shall conform to Articles 312.23-312.28. References in these Articles to subbase and pozzolanic stabilized mixture shall be construed to include base course and pozzolanic stabilized base course, respectively. The subgrade shall be prepared according to Section 301 except Articles 301.04 and 301.05 will not apply.

In addition to the requirements of Article 312.28, transverse joints shall be constructed full plan width of the completed base course and sealed with hot-poured joint sealer. When base course is constructed adjacent to existing pavement, this joint will not be required. Joints shall be located at spacings of 9 m (30 ft.) perpendicular to the centerline. Construction and sealing of the joints shall be performed as shown on the detail drawing included in the plans or as directed by the Engineer.

The base course portion of the joint shall be cut within 72 hours of base course compaction. This portion may be cut separately or in conjunction with the surface course portion if the 72 hour requirement can be met. The location of the joint in the surface portion shall not vary by more than 5 mm (3/16 inch) from the location of the joint in the base course.

Sealing of the surface course joints shall be performed according to Section 420.14(a), except that sealing shall commence immediately upon sawing of the joint.

The finished base course may be opened to local traffic 36 hours after the finishing operation unless otherwise directed by the Engineer and to all traffic after placement of surface course.

Contraction joints shall be established in all base removed and replaced over 9 m (30 ft.) in length.

**357.05 Tolerance in Thickness.** Tolerance in pozzolanic stabilized base course thickness shall be as specified in Article 352.16. The reference to soil-cement base course in Article 352.16 shall be construed as including pozzolanic stabilized base course.

#### 357.06 Method of Measurement.

- (a) Contract Quantities. The requirements for the use of contract quantities shall conform to Article 202.07(a).
- (b) Measured Quantities. Pozzolanic stabilized base course of the thickness specified will be measured for payment in place and the area computed in square meters (square yards). The width for measurement will be the width of the top of the base course as shown on the plans or as directed by the Engineer. The liquid asphalt for the curing coat, any sand required, and the construction and sealing of contraction joints will not be measured for payment, but shall be considered as included in the contract unit price bid for Pozzolanic Stabilized Base Course.

**357.07 Basis of Payment.** This work will be paid for at the unit price per square meter (square yard) for POZZOLANIC STABILIZED BASE COURSE, of the thickness specified.

# SECTION 358. REPAIR AND PREPARATION OF BASE COURSE

- **358.01 Description.** This work shall consist of the repair and preparation of existing surfaces, which are to be used as bases for the various types of surface courses.
- **358.02 Materials.** Materials shall meet the requirements of the following Article of Section 1000 Materials:

		Item	Article/Section	on
(a)	Aggregate		1004.0	)4

**358.03 Equipment.** Equipment shall meet the requirements of the following Articles of Section 1100 - Equipment:

	Item	Article	/Section
(a)	Pneumatic-Tired Roller		1101.01
(b)	Mechanical Sweeper		1101.03

#### **CONSTRUCTION REQUIREMENTS**

### 358.04 Aggregate Bases.

- (a) General. All loose materials on the surface of the proposed base course which are of such size, gradation and quality that they can be utilized, shall be bladed to the shoulders and left in windrows together with any material already in windrows or stockpiles. All such materials shall be incorporated in the work or disposed of as directed by the Engineer. The repair and preparation of newly constructed bases shall not be undertaken until it has been opened to traffic for a period of not less than 10 days.
- (b) Repairs. All failures (potholes, deep depressions or ruts) occurring in the existing surface to be used as the base, shall be repaired by scarifying, removing all foreign material and reshaping. If additional material is needed to bring the surface to the required cross section, CA-6 aggregate shall be used. The repaired areas shall then be compacted thoroughly by means of a pneumatic-tired roller or a hand tamper as directed by the Engineer. If the moisture content of the aggregate is such that compaction satisfactory to the Engineer cannot be obtained, water shall be added.
- (c) Preparation. After the repairs have been made in the base course, any area having ruts, depressions, corrugations, excessive crown or loose material, shall be brought to a smooth grade and proper crown by repeatedly wetting with water applied by means of a sprinkler, blading with a road grader or multiple blade maintainer, and rolling with a pneumatic-tired roller. The base course shall be bladed lightly to such a depth that sufficient material will be obtained to true up the surface of the

Art. 358.04

base course. During the smoothing operations, the roadbed from the edges of the base to the shoulder lines shall be bladed to a smooth uniform slope so that the surface will drain and not impound water.

After the surface of the base course has been brought to a smooth grade and proper crown, it shall be compacted by repeated wetting and rolling with a pneumatic-tired roller for a period of not less than 2 days. During this time, the surface shall be kept in a damp condition. Before a prime coat is applied, the base shall be surface dry, but at no time shall the period of drying be less than 24 hours. When required by the Engineer, the base course shall be swept with a mechanical sweeper or hand brooms before a prime coat is applied. The sweeping shall be continued until all dust, mud and foreign material are removed. Traffic shall not be allowed upon the prepared base course after the final sprinkling, or, if a bituminous prime coat has been applied, until the Engineer has approved the penetration of the prime coat.

### 358.05 Old Bituminous, Brick and Concrete.

- (a) Repair. All loose and defective material shall be removed from all holes, ruts or depressions in the existing surface. These areas shall then be filled as provided in the contract.
- (b) Preparation. After the base course has been patched and permitted to cure, it shall be cleaned by means of a mechanical sweeper, hand brooms, flushing with water, or by other approved methods. Special care shall be taken to clean the surface of the base course adjacent to the edges, so that the full width of the surface to be treated will be clean. The surface of the base course shall be clean and dry when the surface course is placed.

#### 358.06 Method of Measurement.

- (a) Contract Quantities. The requirement for use of contract quantities shall be according to Article 202.07(a).
- (b) Measured Quantities. The work in connection with the repair and preparation of bases, except materials, will be measured for payment in place and the area computed in square meters (square yards).

If additional material is required for the repair of aggregate bases, it will be measured for payment in metric tons (tons) according to the requirements of Article 311.08(b).

If additional material is required for the repair of old bituminous, brick, or concrete bases, it will be measured for payment as provided for in the contract.

**358.07 Basis of Payment.** The work in connection with the repair and preparation of bases, except materials, will be paid for at the contract unit price per square meter (square yard) for PREPARATION OF BASE.

Additional material required for the repair of aggregate bases, will be paid for at the contract unit price per metric ton (ton) for AGGREGATE BASE REPAIR.

# Repair and Preparation of Base Course

Art. 358.07

When the contract does not contain a unit price for the material required for the repair of any type base, it will be paid for according to Article 109.04.

# SECTION 400. SURFACE COURSES, PAVEMENTS, REHABILITATION AND SHOULDERS

#### **BITUMINOUS SURFACES AND PAVEMENTS**

#### SECTION 401. BITUMINOUS TREATED EARTH SURFACE

- **401.01 Description.** This work shall consist of preparing an earth surface and applying bituminous materials.
- **401.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 Materials:

	Item	Article/Section
(a)	Bituminous Materials (Note 1)	1009.01-1009.04, 1009.09-1009.11
(b)	Blotter Aggregate	1004.06

Note 1. The Contractor may use any one of the types of bituminous materials as shown in the table below. When more than one grade is shown on a particular type, the Engineer reserves the right to specify the grade which shall be used.

Bituminous Material	Grade
Medium Curing Liquid Asphalt	MC-30, MC-70 MC-250, MC-800
Slow Curing Liquid Asphalt	SC-70, SC-250 SC-800
Road Oil	E-2, E-3, E-4

#### **CONSTRUCTION REQUIREMENTS**

- **401.03 Preparation of Earth Surface.** The earth grade shall be reshaped prior to the application of the bituminous materials, and at the time the bituminous material is applied, the surface shall be smooth, well compacted, free from sod, vegetation, excess loose dirt or dust, and shall be dry enough that the wheels of the distributor will not rut or mar the surface. As soon as the road is closed to traffic and before application of the bituminous material, excess dust and loose dirt shall be either removed from the surface, or the surface wetted sufficiently to cause the excess dust or loose dirt to be consolidated with the solid soil beneath. If the removal of the dust and loose dirt leaves an uneven or rough surface, the earth grade shall be restored to a condition satisfactory to the Engineer.
- **401.04 Weather Limitations.** This work shall be done between May 1 and October 1. Bituminous materials shall be applied only when the temperature of the

air in the shade is above 15 °C (60 °F.). No work shall be started if local conditions indicate that rain is imminent.

This work may be done between October 1 and October 30 providing the temperature of the air for 3 consecutive days immediately preceding the day of application has been, (1) above 15 °C (60 °F.) in the shade each day, (2) a minimum of 5 °C (40 °F.) and (3) the temperature of the air in the shade at time of application is above 15 °C (60 °F.).

- **401.05 Quantity of Bituminous Material.** The total quantity of bituminous material applied shall be not less than 1  $L/m^2$  (0.25 gal. per sq. yd.) nor more than 3  $L/m^2$  (0.75 gal. per sq. yd.), as required by the Engineer.
- **401.06 Application of Bituminous Material.** The temperature of the bituminous material at the time of application shall be such that it will spray uniformly without clogging the spraying nozzles and shall be applied within the temperature ranges indicated in Article 403.07. All flames shall be extinguished during application of the bituminous material.

The bituminous material shall be applied by means of a pressure distributor meeting the approval of the Engineer.

Where the total quantity of bituminous material to be applied is 2 L (0.4 gal.) or more per m<sup>2</sup> (sq. yd.), it shall be applied in 2 applications. Sufficient time shall elapse between successive applications to permit the bituminous material to be absorbed to such extent that the soil will not adhere to the wheels of the distributor.

- **401.07 Application of Blotter Aggregate.** When specified, an application of a blotter aggregate shall be applied to the treated surface immediately after the application of the bituminous materials. The blotter aggregate shall be spread evenly with an aggregate spreader, meeting the approval of the Engineer, over the entire surface at the rate of 8-16 kg/m² (15-30 lbs. per sq. yd.), the exact rate to be specified by the Engineer. The blotter aggregate shall be applied by spreader equipment operating backwards over the aggregate being placed. Hand spreading will be permitted only when approved by the Engineer.
- **401.08** Opening to Traffic. The road shall be opened to traffic according to Article 701.05(c)(4).
- **401.09 Method of Measurement.** The bituminous material will be measured as specified in Section 1009. The unit of measurement will be shown on the plans.

The blotter aggregate will be measured in metric tons (tons) according to the requirements of Article 311.08(b), except payment will not be made for blotter aggregate in excess of 110 percent of the amount specified by the Engineer.

**401.10 Basis of Payment.** This work will be paid for at the contract unit price per liter (gallon) for BITUMINOUS MATERIAL APPLIED or at the contract unit price per metric ton (ton) for BITUMINOUS MATERIAL APPLIED and per metric ton (ton) for BLOTTER AGGREGATE.

#### SECTION 402. AGGREGATE SURFACE COURSE

**402.01 Description.** This work shall consist of furnishing and placing one or more courses of aggregate upon a prepared subgrade.



**402.02 Materials.** Materials shall meet the requirements of the following Article of Section 1000 - Materials:

		Item	Article	/Section
(a)	Aggregate			1004.04

**402.03 Equipment.** Equipment shall meet the requirements of the following Articles of Section 1100 - Equipment:

	Item	Article/Section
(a)	Tamping Roller	1101.01
(b)	Pneumatic-Tired Roller	1101.01
	Three-Wheel Roller (Note 1)	
(d)	Tandem Roller (Note 1)	1101.01
(e)	Spreader	1102.04
(f)	Vibratory Machine (Note 2)	



Note 1. Three-wheel or tandem rollers shall weigh 5.5 to 9 metric tons (6 to 10 tons) and shall weigh not less than 35 N/mm (200 lbs. per inch) nor more than 55 N/mm (325 lbs. per inch) of width of the roller.

Note 2. The vibratory machine shall meet the approval of the Engineer.

#### CONSTRUCTION REQUIREMENTS

- **402.04 Subgrade.** The subgrade shall be prepared according to Section 301 except Articles 301.04 and 301.05 will not apply.
- **402.05 Type A Requirements.** Aggregate surface course, Type A, shall be constructed according to Article 351.05(a) and (b) except the bearing ratio requirements shall not apply.
- **402.06 Tolerance in Surface Course Type A Thickness.** The surface course shall be constructed to the thickness shown on the plans. Thickness determinations will be made at such points as the Engineer may select. When the constructed thickness is less than 90 percent of the thickness shown on the plans, aggregate shall be added to obtain the required thickness.
- **402.07 Type B Requirements.** Any 1 or 2 gradations of the material specified in Article 1004.04 shall be used except where 2 gradations of material are used, the change shall not be made at more than one location on the section.

The surfacing material shall be deposited on the subgrade by means of a spreader.

The equipment used shall be such that the required amount of material will be deposited uniformly along the central portion of the roadbed.

The material which has been deposited shall be spread immediately to the plan

cross section. Hauling shall be routed over the spread material so it will cover the entire width of surface. If the equipment used in the hauling operations causes ruts extending through the spread material and into the subgrade, and the subgrade material is being mixed with the surfacing material, the equipment shall be removed from the work or the rutting otherwise prevented as directed by the Engineer.

The Contractor shall keep the surface smooth by dragging or blading as many times each day as the Engineer may direct.

Holes, waves, and undulations which develop and which are not filled by blading shall be filled by adding more material.

- **402.08** At Bridges, Railroad Grade Crossings, and Existing Pavement. The surface course adjacent to bridges, railroad grade crossings, and existing pavement shall have a trench type cross section of the same thickness as the typical section, with the surface at the established grade. The width at bridges and railroad grade crossings shall be 600 mm (2 ft.) wider than the portion of the featheredge section having a uniform thickness. At existing pavement, the width shall be as shown on the plans or as directed by the Engineer. The transition from the featheredge design to the trench design at the bridge, railroad grade crossing or existing pavement shall be made at a uniform rate within a distance of 15 m (50 ft.). The cost of excavation in this transition will be considered as included in the cost of surfacing.
- **402.09** At Side Roads, Entrances, and Mailboxes. The same type and gradation of material used for constructing the surface course shall be used at side roads, entrances, and mailbox turnouts.
- **402.10 For Temporary Access.** The Contractor shall construct and maintain an aggregate surface course for temporary roads, approaches, and entrances according to Article 402.07 and as directed by the Engineer.

The same type and gradation of material used to construct the temporary access shall be used to maintain it.

When use of the temporary access is discontinued, the surface aggregate used in its construction shall be removed and utilized in the permanent construction or disposed of according to Article 202.03.

- **402.11 Shaping, Trimming and Finishing.** All shaping, trimming, and finishing shall be according to Section 212.
- **402.12 Method of Measurement.** Aggregate used for aggregate surface course will be measured for payment in metric tons (tons), cubic meters (cubic yards), or square meters (square yards) of the thickness specified, according to the requirements of Article 311.08.
- **402.13 Basis of Payment.** This work will be paid for at the contract unit price per metric ton (ton) for AGGREGATE SURFACE COURSE, TYPE A, or AGGREGATE SURFACE COURSE, TYPE B; or at the contract unit price per cubic meter (cubic yard) for AGGREGATE SURFACE COURSE, TYPE A; or AGGREGATE SURFACE COURSE, TYPE B; or at the contract unit price per square meter (square yard) for AGGREGATE SURFACE COURSE, TYPE A; of the thickness specified.

The unit price bid for Aggregate Surface Course, Type B, shall include constructing, maintaining, and removing temporary access and the utilization or disposal of the removed material.

# SECTION 403. BITUMINOUS SURFACE TREATMENT (CLASS A-1, A-2, A-3)

- **403.01 Description.** This work shall consist of the construction of a single or multiple course bituminous surface treatment as indicated below:
  - (a) A-1. A-1 shall consist of a bituminous seal coat material and a seal coat aggregate.
  - (b) A-2. A-2 shall consist of a prime coat, a bituminous cover coat material and a cover coat aggregate, and a bituminous seal coat material and seal coat aggregate.
  - (c) A-3. A-3 shall consist of a prime coat, two separate applications of a bituminous cover coat material and cover coat aggregate, and a bituminous seal coat material and seal coat aggregate.
- **403.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 Materials:

	Item	Article/Section
(a)	Cover Coat Aggregate	1004.03
(b)	Seal Coat Aggregate (Note 1	) 1004.03
(c)	Bituminous Materials (Note 2	) 1009

- Note 1. For A-1 surface treatment, the Special Provisions will specify which of the 2 aggregate gradations itemized in Article 1004.03 shall be used.
- Note 2. For A-1 surface treatment, the Special Provisions will specify the types and grades of bituminous materials to be used. For A-2 and A-3 surface treatments, the Contractor may use any one of the types of bituminous materials shown in the following table. When more than one grade is shown for a particular type, the Engineer reserves the right to specify the grade which shall be used.



Type of Construction	Bituminous Materials Recommended for Weather Conditions Indicated	
	Warm [15 °C to 30 °C]* [(60 °F. to 85 °F.)]*	Hot [(30 °C Plus]* [(85 °F. Plus)]*
Prime	MC-30, PEP	MC-30, PEP
Cover Coat and Seal Coat	RS-1, RS-2, CRS-1, CRS-2, RC-800, RC-3000, MC-800, MC-3000, SC-3000, HFE-90, HFE-150, HFE-300	RS-1, RS-2, CRS-1, CRS-2, RC-800, RC-3000, MC-800, MC-3000, SC-3000, AC 2.5, AC 5, HFE-90, HFE-150 HFE-300

<sup>\*</sup>Temperature of the air in the shade at the time of application.

**403.03 Equipment.** Equipment shall meet the requirements of the following Articles of Section 1100 - Equipment:

	Item	Article/Section
(a)	Pneumatic-tired Roller	1101.01
	Mechanical Sweeper	
(c)	Aggregate Spreader	1102.04
(d)	Heating Equipment	1102.07
(e)	Pressure Distributor	1102.05

### **CONSTRUCTION REQUIREMENTS**

**403.04 Weather Limitations.** This work shall be done between May 1 and October 1. Bituminous materials shall be applied only when the temperature of the air in the shade is above 15  $^{\circ}$ C (60  $^{\circ}$ F.). No work shall be started if local conditions indicate that rain is imminent.

This work may be done between October 1 and October 30 providing the temperature of the air for 3 consecutive days immediately preceding the day of application has been: (1) above 15  $^{\circ}$ C (60  $^{\circ}$ F.) in the shade each day, (2) a minimum of 5  $^{\circ}$ C (40  $^{\circ}$ F.) and (3) the temperature of the air in the shade at time of application is above 15  $^{\circ}$ C (60  $^{\circ}$ F.).

# Bituminous Surface Treatment (Class A-1, A-2, A-3)

Art. 403.05

- **403.05 Sequence of Work.** The sequence of construction operations shall be undertaken as follows:
  - (a) Repair and preparation of base or existing surface.
  - (b) Application of bituminous material for prime coat (A-2 and A-3 only).
  - (c) Alternate applications of bituminous material and aggregate.
- **403.06** Repair and Preparation of Base or Existing Surface. The base or existing surface shall be prepared according to Section 358.
- 403.07 Preparation of Bituminous Material. The temperature of the bituminous material at the time of application shall be such that it will spray uniformly without clogging the spraying nozzles and shall be applied within the temperature ranges indicated in the table below. Bituminous material delivered in tank cars may be heated by steam coils; that delivered in mobile tanks may be heated in asphalt tanks or in a pressure distributor. In all cases, precautions shall be taken to avoid danger of fire. If heated in asphalt tanks, the material shall be agitated during the heating period to prevent localized overheating. If heated in a pressure distributor, the material shall be circulated while it is being heated. All flames shall be extinguished during application of the bituminous material. In all methods of heating, means shall be provided to determine the temperature of the material at frequent intervals to prevent it from being overheated or damaged. Emulsified asphalt received in tank cars or mobile tanks shall be agitated to secure uniformity of the emulsion before being used. Penetrating emulsified prime (PEP) shall be thoroughly agitated within 24 hours of application.



# Bituminous Surface Treatment (Class A-1, A-2, A-3)

(5,005 / 1,7 / 2,7 / 5)		
	Spraying Application Temperature Ranges	
Type and Grade of Bituminous Material	Min./Max., °C	Min./Max., °F.
PEP MC-30 MC-70,RC-70,SC-70 MC-250,RC-250,SC-250 MC-800,RC-800,SC-800 MC-3000,RC-3000,SC-3000 AC 2.5 AC 5 RS-1,CRS-1 RS-2,CRS-2 MS-2,CMS-2 SS-1,SS-1h,CSS-1,CSS-1h HFE-90,HFE-150,HFE-300 E-2 E-3 E-4	15-55 30-90 50-105 75-130 95-150 110-175 135-195 140-200 25-55 45-70 40-70 25-55 60-70 30-90 50-105 75-130	60-130 85-190 120-225 165-270 200-305 230-345 275-385 285-395 75-130 110-160 100-160 75-130 140-160 85-190 120-225 165-270

**403.08** Preparation of Aggregate. The aggregates used in the cover coat(s) and the seal coat shall contain no free moisture. Aggregate that is slightly damp shall be spread in place on the treated road surface and shall be permitted to dry to the satisfaction of the Engineer before it is disturbed.

**403.09 Application of Bituminous Material.** The bituminous material shall be applied with a pressure distributor. A hand spray bar shall be used at places which are not covered by the distributor. The entire length of the spray bar shall be set at the height above the surface recommended by the manufacturer for even distribution of the bituminous material. Any loss of bituminous material in handling due to faulty valves, leaking pipes, overflow due to excess, or other reasons, will be deducted from the amount due the Contractor.

The distributor shall be operated in a manner such that missing or overlapping will be avoided. To prevent overlapping of successive applications of bituminous material at transverse joints, heavy paper shall be spread over the previously applied bituminous material and aggregates. In order to obtain a uniform application of the bituminous material, the distributor shall be traveling at the speed required for the specified rate of application when the spray bar crosses the paper.

Adjacent construction, such as concrete pavement, curb and gutter, bridge floors and bridge handrails, shall be protected by shields, covers or other means. If bituminous material is applied to adjacent construction either by accident or because of inadequate protection, the Contractor shall remove such material to the satisfaction

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of the Engineer.

If the Contractor is unable to obtain satisfactory application due to unsuitable or poorly regulated distributing equipment, or to incompetent operators, the Contractor shall immediately replace or repair such equipment, or furnish competent operators.

A spray bar operator shall be present at all times, on the rear platform of the distributor, during the application of the bituminous material.

The spray bar operator may be omitted from the rear platform, if the distributor is of such design that the quantity of bituminous material being placed is mechanically coordinated with the speed of the distributor, and the on-off controls and driver's visibility are such that no overlapping of successive applications of bituminous material and aggregates will occur.

- **403.10 Application of Aggregates.** The cover coat and seal coat aggregates shall be spread evenly with an aggregate spreader over the entire surface being treated. In all cases, the aggregate shall be applied ahead of the truck or spreader wheels. Hand spreading will be permitted only when approved by the Engineer and, when so permitted, the aggregate shall be spread uniformly and at the approximate rate specified. Any ridges of aggregate left by the aggregate spreader shall be smoothed out with hand brooms immediately behind the aggregate spreader.
- The base shall be surface dry, free from dust and 403.11 Prime Coat. compacted before the prime coat of bituminous material is applied. After the base has been prepared, and when in a warm, dry condition, the bituminous material, as specified for prime in Article 403.02, shall be applied uniformly at the rate of 1 to 2 L/m<sup>2</sup> (0.25 to 0.5 gal. per sq. yd.), the rate to be specified by the Engineer. The bituminous priming material shall be applied to a width 300 mm (1 ft.) greater on each side of the roadway than the specified width of the finished surface. The prime coat shall be permitted to cure until the penetration has been approved by the Engineer, but at no time shall the curing period be less than 24 hours. Pools of bituminous material occurring in the depressions shall be broomed or squeegeed over the surrounding surface the same day the prime coat is applied. At no time during the period of curing shall traffic be allowed upon the primed surface of the road. At locations where the prime coat has failed, it shall be repaired in a manner satisfactory to the Engineer. If the primed surface is damaged by the Contractor's operations, he/she shall repair and roll it at the Contractor's expense. The prime coat shall be maintained at all times until the cover coat is constructed. If required by the Engineer, the primed surface shall be swept prior to constructing the cover coat.
- **403.12 Cover Coat.** Bituminous material for the cover coat shall not be applied until the previous application is acceptable to the Engineer.

At the beginning of each day's work, no bituminous material shall be applied until there is sufficient cover coat aggregate in trucks at the work site to completely cover the first application of bituminous material. The amount of surface area covered by each successive application of bituminous material shall be determined by the Engineer. In no case shall this area be greater than can be covered with cover coat aggregate and given the initial rolling while the bituminous material is still in condition to hold the aggregate.

The bituminous material, as specified for cover coat in Article 403.02, shall be

applied uniformly over the surface at the rate of 1 to 2 L/m² (0.20 to 0.5 gal. per sq. yd.), the rate to be specified by the Engineer. Immediately following the application of the bituminous material, the cover coat aggregate shall be spread over the treated surface at the rate of 8 to 14 kg/m² (15 to 25 lbs. per sq. yd.), the rate to be as specified by the Engineer.

When the aggregate is dry as specified in Article 403.08, the entire surface shall be rolled immediately with a pneumatic-tired roller. Rolling shall proceed in a longitudinal direction beginning at the edges and progressing toward the center, overlapping on successive trips by at least 1/2 the width of the roller. The roller shall be operated at a speed which will not cause the aggregate to be displaced. The aggregate shall then be rolled with a separate pneumatic-tired roller until the aggregate is properly seated in the bituminous material.

**403.13 Seal Coat.** When constructing A-2 or A-3, the seal coat shall not be started until the cover coat immediately preceding the seal coat is completed.

Application of the bituminous material and aggregate and rolling of the seal coat aggregate shall be the same as specified above in Article 403.12 for the cover coat.

During the construction period, the Contractor shall maintain the completed work. If necessary, the Contractor shall apply additional seal coat aggregate to absorb excess bitumen appearing on the surface and shall repair any areas where pickup has occurred.

Upon completion of the work, and after final set of the asphalt, excesses of loose aggregate shall be removed by brooming the entire roadway surface with rotary type brooms.

- **403.14 Opening to Traffic.** The road shall be opened to traffic according to Article 701.05(c)(5).
- **403.15 Method of Measurement.** Bituminous materials will be measured for payment as specified in Section 1009.

Cover Coat Aggregate and Seal Coat Aggregate will be measured in metric tons (tons) according to the requirements of Article 311.08(b), except that measurement for payment will not be made for aggregate in excess of 110 percent of the amount specified by the Engineer.

**403.16 Basis of Payment.** This work will be paid for at the contract unit prices per liter (gallon) for BITUMINOUS MATERIALS (PRIME COAT) and BITUMINOUS MATERIALS (COVER AND SEAL COATS) or at the contract unit prices per metric ton (ton) for BITUMINOUS MATERIALS (PRIME COAT) and BITUMINOUS MATERIALS (COVER AND SEAL COATS), and per metric ton (ton) for COVER COAT AGGREGATE and SEAL COAT AGGREGATE.

When provided as a payment item, the preparation of the base or existing surface will be measured and paid for as specified in Section 358. If not provided as a payment item, preparation of base or existing surface shall be considered as included in the contract unit price(s) for the bituminous surface treatment, and no additional compensation will be allowed.

## SECTION 404. BITUMINOUS SURFACE ROAD MIX (CLASS B)

**404.01 Description.** This work shall consist of constructing a bituminous surface consisting of a mixture of aggregates and bituminous material blended together by road mixing or a traveling plant on a prepared base. If required by the Special Provisions, a seal coat shall be applied to the bituminous surface.

**404.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 - Materials:

	Item	Article/Section
(a)	Aggregate	1004.03
(b)	Seal Coat Aggregate	1004.03
	Bituminous Material (Note 1)	

Note 1. The Contractor may use any one of the types of bituminous materials as listed in the table below. When more than one grade is shown for a particular type, the Engineer reserves the right to specify the grade which shall be used.



Type of Construction		Bituminous Materials Recommended for Weather Conditions Indicated	
		Warm [15 to 30 °C]* [(60 to 85 °F.)]*	Hot [30 °C Plus]* [(85 °F. Plus)]*
Prime		MC-30, PEP	MC-30, PEP
Bituminous Surface Road Mix  With road grader or road mixer		MC-250, MC-800 SC-250, SC-800, MS-2, SS-1 CMS-2, CSS-1 HFE-150, HFE-300  MC-800 SC-800 MS-2, SS-1 CMS-2, CSS-1, HFE-150, HFE-300 RS-1, RS-2	MC-800 SC-800 MS-2, SS-1 CMS-2, CSS-1 HFE-150, HFE-300  MC-800 SC-800 MS-2, SS-1 CMS-2, CSS-1 HFE-150, HFE-300 RS-1, RS-2
Seal Coat when required by Special Provisions)		RC-800, RC-3000 MC-800, MC-3000 SC-3000 CRS-1, CRS-2 HFE-90, HFE-150 HFE-300	RC-800, RC-3000 MC-3000 SC-3000 AC 2.5 AC 5 CRS-1, CRS-2 HFE-90, HFE-150 HFE-300

<sup>\*</sup>Temperature of the air in the shade at the time of application.

**404.03 Equipment.** Equipment shall meet the requirements of the following Articles of Section 1100 - Equipment:

	Item	Article/Section
(a)	Three-Wheel Roller (Note 1)	) 1101.01
(b)	Tandem Roller (Note 1)	1101.01

(c)	Pneumatic-Tired Roller	1101.01
(d)	Mechanical Sweeper	1101.03
(e)	Traveling Plant	1102.02
(f)	Aggregate Spreader	1102.04
(g)	Pressure Distributor	1102.05
(h)	Road Mixer	1102.06
(i)	Heating Equipment	1102.07
(j)	Drag	1102.08
(k)	Windrow Evener	1102.09
(l)	Grader	1102.10

Note 1. The three-wheel or tandem rollers shall weigh 5.5 to 9 metric tons (6 to 10 tons).

### **CONSTRUCTION REQUIREMENTS**

**404.04 General.** This work shall be done only between May 1 and October 1. Bituminous materials shall be applied and bituminous mixtures shall be placed only when the temperature of the air in the shade is above 15  $^{\circ}$ C (60  $^{\circ}$ F.). No work shall be started if local conditions indicate that rain is imminent.

Rolling of the bituminous mixture shall be done with a three-wheel or tandem roller.

All surfaces shall be cleaned of dirt, debris, and loose material prior to placing any bituminous material or bituminous mixture.

- **404.05 Sequence of Work.** The construction operations shall be undertaken in the following sequence:
  - (a) Repair and preparation of base.
  - (b) Preparation and application of bituminous material for prime coat.
  - (c) Proportioning and placing aggregate.
  - (d) Preparation of bituminous mixture.
  - (e) Spreading and rolling bituminous mixture.
  - (f) Construction of seal coat, if required by Special Provisions.
- **404.06 Repair and Preparation of Base.** The base shall be prepared according to Section 358.
- **404.07** Preparation and Application of Bituminous Material for Prime Coat. The bituminous material for prime coat shall be prepared according to Article 403.07 and applied according to Articles 403.09 and 403.11.
- **404.08** Proportioning and Placing of Aggregate. If the aggregate consists of a single graded aggregate within the limits specified, the Engineer will notify the Contractor as to the quantity of aggregate per station to be placed in the windrow.

If a single graded aggregate is used for the mixture, it shall be placed in a uniform windrow by means of an aggregate spreader.

If 2 or more gradations of aggregates are blended for the mixture, the Engineer will determine the proportions necessary to obtain an aggregate uniformly graded within the limits specified, and will notify the Contractor as to the quantity per station of each that shall be placed in the windrow.

If 2 or more gradations of aggregates are blended for the mixture, each gradation shall be placed in a uniform windrow with an aggregate spreader meeting the approval of the Engineer and then mixed thoroughly and placed in a windrow. If small quantities of aggregate are to be added to the windrow, and it is not feasible to use an aggregate spreader, they shall be placed by methods approved by the Engineer.

Aggregate shall not be hauled when the weather or road conditions are such that the hauling operations will cause cutting up or rutting of the base.

**404.09 Preparation of Bituminous Mixture.** The aggregate shall be relatively free of surface moisture. If necessary to reduce the moisture content, the aggregate shall be aerated by blading the aggregate back and forth across the base until the moisture content has been reduced to the satisfaction of the Engineer. Immediately before the application of the bituminous material, the aggregate shall be shaped with a windrow evener. The windrow evener shall be adjusted so that the windrowed aggregate will have the desired uniform cross section.

The aggregate and bituminous material shall be mixed with graders, road mixers, traveling plants, or other equipment approved by the Engineer. When graders are used, not less than 2 will be required for each 800 m (1/2 mile) or fraction thereof under preparation at one time.

The bituminous material used in the bituminous mixture shall be according to Article 404.02. Bituminous material shall be added to the aggregate at a rate of 3.5 to 5.5 percent by weight of total mixture; the percentage will be set by the Engineer. The percent of bituminous material shall be based upon the residual bitumen content.

The aggregate and bituminous material shall be mixed so that a homogeneous mixture is obtained in which all particles of the aggregate are coated uniformly.

(a) Grader and Road-Mixer Methods. When graders or road mixers are used for mixing, the windrow of aggregate shall be flattened before applying the bituminous material. The bituminous material shall be applied by means of a pressure distributor. There shall be at least 3 applications of bituminous material. The first application shall not exceed 1/2 of the total quantity required. In general, the mixing operations shall be carried on in the central portion of the base. The mixing operations shall not be closer than 450 mm (18 inches) to the edges of the existing or new base. When mixing has been carried on in such a manner that at the time of the second or subsequent application of bituminous material, the layer of mixed material is not uniform in cross section, the mixed material shall be reshaped to a uniform cross section by means of a windrow evener or other equipment approved by the Engineer, so that the bituminous material is applied to the mixed material at a uniform rate.

When graders are used for mixing, the treated aggregate shall be given a preliminary mixing with either a spring-tooth harrow, a disk or a rotary speed mixer meeting the approval of the Engineer immediately after each application of bituminous material. After the preliminary mixing of the

aggregate and bituminous material, the mixing shall be continued with graders. The windrow shall be moved from one side of the primed base to the other until the mixture is free from lumps, homogeneous, and of uniform color. When longitudinal drifting of material occurs, the direction of mixing operations shall be varied, or other methods used, so as to obtain a windrow of uniform cross section.

When road mixers are used for mixing, the treated aggregate shall be mixed after each application of bituminous material. Mixing shall be continued until the mixture is free from lumps, homogeneous, and of uniform color. When the total amount of aggregate necessary to construct the surface to the specified width and depth cannot be mixed at one time, it shall be mixed in portions and the mixed portions placed in a windrow on one side of the base; in which case, after mixing is completed with the road mixer, the total mixed material shall be mixed and blended with a grader until it is uniform in color, consistency and gradation.

The mixing shall be performed in such a manner as to prevent segregation of the various aggregate sizes or loss of the fine aggregate, and to agitate the entire mixture but not disturb the base. The mixture shall be kept within the limits of the base, and no earth or other foreign matter shall be permitted in the mixture. When the work is more than 1600 m (1 mile) in length, the train of mixing equipment shall travel at least 800 m (1/2 mile) before turning around.

If, after mixing, it is the Engineer's decision that the mixture does not contain the proper amount of bituminous material, more bituminous material or aggregate shall be added according to the Engineer's directions, and mixing continued until the bituminous mixture is homogeneous and uniform in color. After the bituminous mixture has been prepared as required, it shall be windrowed on one side of the prepared base. The windrow shall be uniform in size.

(b) Traveling-Plant Method. When traveling plants are used for mixing, the amount of bituminous material applied will be designated by the Engineer and may be adjusted by the Engineer as the work progresses. Material which may fall outside, or which is not picked up by the conveyor, shall be picked up by hand labor and thrown directly into the elevating unit and not onto the windrow ahead. The application of bituminous material shall be made in such a manner that the resulting mixture will be homogeneous and uniform in color.

The use of a windrow evener may be omitted when mixing is done with a traveling plant. The feed control of the traveling plant will be calibrated and set by the Engineer.

If one operation of the traveling plant does not produce a uniform bituminous mixture, the windrow shall be remixed with the traveling plant, grader, road mixer or by other methods approved by the Engineer, until the bituminous mixture is uniform in texture and color. If the mixture does not contain the proper amount of bituminous material, additional bituminous material or aggregate shall be added and the windrow remixed as specified herein.

- **404.10 Spreading of Bituminous Mixture.** After the mixture has been prepared, windrowed, and cured, it shall be divided into 2 equal parts with motor graders having end plates attached to the blades. One part shall be bladed across the centerline and spread uniformly upon that portion of the base. The remaining portion of the windrow shall be spread uniformly upon the other portion of the base. Spreading shall be done so segregation shall be kept to a minimum, and the finished surface will be smooth and of uniform texture. The mixture shall be spread to a true line along the edges of the pavement. Care shall be taken to smooth out junctions of successive operations.
- If, after spreading the mixture, there are any portions which are not homogeneous, do not contain sufficient bituminous material, or contain an excess of bituminous material, such portions shall be corrected as directed by the Engineer.

Unless the mixture can be spread to the final cross section and rolled the same day as mixed, it shall be left in the windrow. Should rain fall during road-mixing operations, or after the mixture has been spread and before it has been rolled, the mixture shall be windrowed and not disturbed until the base contains no visible moisture. The mixture shall then be bladed back and forth across the base until the moisture in the mixture has been removed to the satisfaction of the Engineer.

**404.11 Compaction of Bituminous Mixture.** After the mixture has been spread and when it will bear the weight of the roller without excess lateral movement, it shall be rolled longitudinally. Rolling shall start at the edges and progress toward the center, overlapping on successive trips by at least 1/2 the width of the roller. The entire surface shall be rolled twice in this manner, unless in the opinion of the Engineer, additional rolling is necessary. Final rolling shall be accomplished by one passage of the roller along each edge of the pavement. The edges shall be compacted to form an angle of approximately 45 degrees with the surface of the bituminous mixture.

All roller wheels shall be moistened lightly with water to prevent bituminous material from sticking to them. If the bituminous surface has absorbed moisture before rolling is completed, it shall be torn up, bladed back and forth across the base until dry and then relaid at the Contractor's expense. When the rolling has been completed and the surface has cured, traffic may be allowed upon it.

- **404.12 Surface Tests.** After the bituminous mixture has been compacted, the surface will be tested for smoothness by means of a 5-m (16-ft.) straightedge placed parallel to the centerline of the pavement, parallel to the grade line in each wheel lane and touching the surface. Ordinates measured from the face of the straightedge to the surface of the pavement shall at no place exceed 10 mm (3/8 inch). If the variation from a true surface exceeds 10 mm (3/8 inch), the entire area so affected shall be corrected as approved by the Engineer.
- **404.13 Seal Coat.** When specified seal coat shall be constructed according to the requirements of Articles 403.07, 403.08, 403.09, 403.10 and 403.13. The seal coat shall not be applied, until the bituminous mixture has been subjected to traffic for a period of not less than 4 weeks. The surface shall be swept clean, removing all dirt, debris, and loose material. It shall be clean and dry when the bituminous material is applied.
- **404.14 Opening to Traffic.** The road shall be opened to traffic according to Article 701.05(c)(6).

**404.15 Method of Measurement.** Bituminous material will be measured as specified in Section 1009.

Aggregate and Seal Coat Aggregate will be measured for payment in metric tons (tons) according to Article 311.08(b), except measurement for payment will not be made for seal coat aggregate in excess of 110 percent of the amount specified by the Engineer.

**404.16 Basis of Payment.** This work will be paid for at the contract unit prices per liter (gallon) for BITUMINOUS MATERIALS (PRIME COAT), BITUMINOUS MATERIALS (ROAD MIX) and BITUMINOUS MATERIALS (SEAL COAT) or per metric ton (ton) for BITUMINOUS MATERIALS (PRIME COAT), BITUMINOUS MATERIALS (ROAD MIX) and BITUMINOUS MATERIALS (SEAL COAT), and per metric ton (ton) for AGGREGATE and SEAL COAT AGGREGATE.

If provided as a payment item, the repair and preparation of the base will be measured and paid for as specified in Section 358. If not provided as a payment item, repair and preparation of base shall be considered as included in the contract unit price for the bituminous surface, and no additional compensation will be allowed.

# SECTION 405. BITUMINOUS SURFACE PLANT MIX (CLASS B)

- **405.01 Description.** This work shall consist of constructing one or more courses of a mixture of aggregates and bituminous material on a prepared base.
- **405.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000:

	Item	Article/Section
(a)	Aggregate	
(b)	RAP Material (Note 1)	
(c)	Bituminous Materials (Note 2)	

Note 1. The original pavement or hot mix bituminous materials need not contain crushed coarse aggregate.

Note 2. The particular type and grade of bituminous material to be used will be specified in the contract. The Contractor may use any one of the types of bituminous materials listed in the table below. When more than one grade is shown for a particular type, the Engineer reserves the right to specify the grade which shall be used.



Type of Construction	Bituminous Materials Recommended	
Prime	MC-30	
Bituminous Surface Plant Mix (Note 1)	SC-800,SC-3000 MC-3000 AC 5, AC 10	

Note 1. When RAP material is used in the mixture, the bituminous material shall be AC 2.5, AC 5 or AC 10.

**405.03 Equipment.** Equipment shall meet the requirements of the following Articles of Section 1100 - Equipment:

	Item Art	icle/Section
(a)	Self-propelled Pneumatic-Tired Roller (Note 1)	1101.01
(b)	Three-Wheel Roller (Note 2)	1101.01
(c)	Tandem Roller (Note 2)	1101.01
(d)	Pneumatic-Tired Roller	1101.01
(e)	Mechanical Sweeper	1101.03
(f)	Heating Equipment	1102.07
(g)	Pressure Distributor	1102.05
(h)	Drier	
(i)	Pugmill-Mixer	1102.01
(j)	Continuous Mixer	
(k)	Temperature Recording Instrument	1102.01
(I)	Spreading and Finishing Machine	1102.03
(m)	Hot-Mix Surge Bins	
(n)	Drier Drum Hot-Mix Plant (Note 3)	1102.01
(o)	Vibratory Roller (Note 4)	1101.01

Note 1. The self-propelled pneumatic-tired roller shall develop a compression of not less than 50 N/mm (300 lbs. per inch) nor more than 90 N/mm (500 lbs. per inch) width of tire tread in contact with the bituminous surface. The tires shall be inflated to an air pressure of not less than 415 kPa (60 psi). When the tires are operating in a hot condition and there is no tire pickup, the water system may be turned off.



- Note 2. The three-wheel or tandem rollers shall weigh 5.5 to 9 metric tons (6 to 10 tons) and develop a unit compression on the compression wheels of not less than 35 N/mm (200 lbs. per inch) nor more than 60 N/mm (350 lbs. per inch) of wheel width.
- Note 3. When a drier-drum hot-mix plant is used to produce Class B surface mixture incorporating RAP material, the plant shall be suitably modified to produce recycled bituminous mixes in a manner approved by the Engineer.



Note 4. The vibratory roller shall develop a total applied force of not less than 35 N/mm (200 lbs. per inch) nor more than 60 N/mm (350 lbs. per inch).

#### CONSTRUCTION REQUIREMENTS

- **405.04 General.** The bituminous mixture shall be constructed only on a dry base under the following conditions unless otherwise authorized in writing by the Engineer:
  - (a) When slow curing asphalts are used;
    - (1) Between May 1 and October 1, and
    - (2) The air temperature in the shade is above 10 °C (50 °F.).
  - (b) When medium curing asphalt is used;
    - (1) Between May 1 and October 15, and
    - (2) The air temperature in the shade is above 5 °C (40 °F.).
  - (c) When asphalt cements are used;
    - (1) The air temperature in the shade is above 5 °C (40 °F.).

No work shall be started if local conditions indicate rain is imminent.

When the aggregate for the bituminous mixture consists of a single graded aggregate, the Contractor shall unload the graded aggregate into the stockpile and shall use only the graded aggregate from the stockpile. In addition, the Contractor shall have available fine or coarse aggregate to be blended with the graded aggregate to the satisfaction of the Engineer when it is necessary to correct nonuniformity in the gradetion of the graded aggregate.

If approved by the Engineer, separate sizes of aggregates may be blended to produce the bituminous mixture. The method of blending shall be by the use of aggregate feeders of the apron, drum, reciprocating, or other type approved by the Engineer, which shall provide for proportional and total feeding of the aggregates. The components of the blend need not be of the same source or of the same kind of material.

The sources of material shall not be changed during the progress of the work without written permission from the Engineer.

All surfaces shall be cleaned of dirt, debris and loose material prior to placing any bituminous material or bituminous mixture.

- **405.05 Sequence of Work.** The construction operations shall be undertaken in the following sequence:
  - (a) Repair and preparation of base.
  - (b) Preparation and application of bituminous material for prime coat.
  - (c) Preparing, transporting, spreading, and rolling bituminous mixture.

- **405.06 Repair and Preparation of Base.** The base shall be prepared according to Section 358.
- **405.07 Preparation and Application of Bituminous Materials.** The bituminous material for prime coat shall be prepared according to Article 403.07 and shall be applied according to Articles 403.09 and 403.11.

The bituminous material for the mixture shall be transferred to the asphalt tanks and heated to the temperatures as follows:

	Temperature		
Type of Bituminous Material	Minimum	Maximum	
Slow Curing Liquid Asphalts	Workable	Not to exceed Flash Point or 135 °C (275 °F.)	
Medium Curing Liquid Asphalts	Workable	Flash Point	
Asphalt Cements	105 °C (225 °F.)	165 °C (325 °F.)	

**405.08 Preparation of Bituminous Mixture.** The aggregates for the bituminous mixture shall be dried and heated in the revolving drier according to the following table when equipment meeting the requirements of Article 1102.01(a) through (d) is used. When a plant meeting the requirements of Article 1102.01(e) is used, the bituminous material shall be asphalt cement with a minimum temperature of 95 °C (200 °F.) and there will be no limitations on moisture of the aggregates.

Bituminous Material	SC	MC	AC
Maximum Moisture	0.5%	1.0%	
Minimum Temperature	95 °C (200 °F.)		120 °C (250 °F.)
Maximum Temperature	135 °C (275 °F.)	105 °C (225 °F.)	165 °C (325 °F.)

The aggregate and bituminous material used in the mixture shall be measured separately and accurately by weight or by volume. The devices used in weighing or measuring the aggregate and bituminous material shall be of a type approved by the Engineer. When the aggregate is in the mixer, the bituminous material shall be added and mixing continued until a homogeneous mixture is produced in which all the particles of the aggregate are coated uniformly. The mixing time will be determined by the Engineer.

The ingredients shall be heated and combined in such a manner and at such a temperature as to produce a mixture which when discharged from the mixer, will not in general, vary more than 10 °C (20 °F.) from the temperature set by the Engineer. The temperature of the bituminous mixture shall not be more than the maximum temperature noted in the above table for the bituminous material being used. The bituminous mixture shall conform to the following composition limits by weight:

Aggregate	(	94.0 to 96.5%
Bituminous Material		. 3.5 to 6.0%

The percentage of bituminous material will be determined by the Engineer. The percentage of bituminous material shall be based upon the residual bitumen content. The percentage of residual bitumen shall be controlled within  $\pm 0.5$  percentage points of the percentage set by the Engineer. The right is reserved to make such changes in the proportions of bituminous material and aggregates as the Engineer may consider necessary within the limits of the specifications.

**405.09 Preparation of Bituminous Mixture Using RAP.** When RAP materials are being used, the RAP material(s), virgin aggregate(s) and asphalt cement shall be proportioned within the following composition limits by weight:

<u>Ingredient</u>	Percent by	Dry	Weigh	<u>ıt</u>
Virgin Aggregate(s)	46	_	93	
RAP Material(s)	0	-	50	
Mineral Filler (if required)	0	-	5	
Bituminous Material	4.0	-	7.0	

The virgin aggregates shall be dried and heated in the drier to a temperature that will produce the specified resultant mix temperature when combined with the RAP material.

The heated virgin aggregates and mineral filler shall be combined with the RAP material in such a manner as to produce a bituminous mixture which when discharged from the mixer shall not vary more than 15 °C (30 °F.) from the temperature set by the Engineer. The combined ingredients shall be mixed for a minimum of 30 seconds or until a homogeneous mixture as to composition and temperature is obtained. For a batch type plant, the standard 15 seconds dry and 30 seconds wet mixing time should normally be used. Variation in wet and dry mixing times may be permitted, depending on the moisture content and amount of RAP material used. The mix temperature shall not exceed 180 °C (350 °F.). Wide variations in the mixture temperature will be cause for rejection of the mix.

The final mixture(s) shall conform to the following Standard Deviations. These deviations will be verified by extraction tests of the final mixture. If these stipulations are not met, the amount of RAP material used shall be reduced by 10 percent increments per day until mix is produced meeting these requirements. When the Contractor is able to produce mixtures within these criteria for 3 consecutive days, the percent of RAP material may again be increased.

Selected Criteria (CA-6)	Standard Deviation 1/	Tole	ran	ce 2/
Passing 25 mm (1 inch) sieve Passing 12.5 mm (1/2 inch) sieve Passing 4.75 mm (No. 4) sieve Passing 1.18 mm (No. 16) sieve Passing 75 μm (No. 200) sieve Passing 75 μm (No. 200) sieve Bitumen	5.0 6.5 5.5 4.5 2.5 2.5			
Selected Criteria (CA-10)	Standard Deviation 1/	<u>Tole</u>	rang	ce 2/
Passing 25 mm (1 inch) sieve Passing 12.5 mm (1/2 inch) sieve Passing 4.75 mm (No. 4) sieve Passing 1.18 mm (No. 16) sieve Passing 75 μm (No. 200) sieve Bitumen	6.5 6.0 5.0 2.5 0.5	15		
Selected Criteria (CA-12)	Standard Deviation 1/	<u>Tole</u>	ran	<u>ce 2</u> /
Passing 12.5 mm (1/2 inch) sieve Passing 9.5 mm (3/8 inch) sieve Passing 4.75 mm (No. 4) sieve Passing 1.18 mm (No. 16) sieve Passing 75 μm (No. 200) sieve Bitumen	5.0 4.0 5.0 4.5 2.5 0.5			_

<sup>1/ -</sup> Represents the Standard Deviation of the overall population.

<sup>2/ -</sup> Individual tests shall be between these tolerances.

The percentage of bituminous material will be determined by the Engineer. The percent of bituminous material shall be based upon the residual bitumen content. The percentage of residual bitumen shall be controlled within +0.5 percent of the percent set by the Engineer. The right is reserved to make such changes in the proportions of bituminous material and aggregates as the Engineer may consider necessary within the limits of the Specifications.

- **405.10 Transportation.** Vehicles used in transporting the bituminous mixtures shall have tight dump bodies which have been previously cleaned of all foreign material and sprayed with asphalt release agents. The beds shall be sprayed with asphalt release agents which have been tested and approved by the Department. After spraying, the bed of the vehicle shall be in a completely raised position and shall remain in this position until all excess release agent has been drained. When the air temperature is below 15 °C (60 °F.), vehicle bodies including the end, endgate, sides and bottom shall be insulated with fiberboard, plywood or other approved insulating material and shall have a thickness of not less than 20 mm (3/4 inch). When the insulation is placed inside the vehicle body, the insulation shall be covered with sheet steel approved by the Engineer. Each vehicle shall be equipped with a cover of canvas or other suitable material meeting the approval of the Engineer which shall be used if any one of the following conditions are present:
  - (a) Ambient air temperature is below 15 °C (60 °F.).
  - (b) The weather is inclement.
  - (c) When asphalt cement is used, the temperature of the bituminous mixture immediately behind the paver screed is below 105 °C (225 °F.).

The cover shall extend down over the sides and ends of the truck for a distance of 300 mm (12 inches) and shall be fastened securely. Bituminous mixture which cannot be spread and compacted during daylight shall not be sent to the work unless artificial light satisfactory to the Engineer is provided. The bituminous mixture shall not be hauled when the weather or road conditions are such that the hauling operations will cause cutting up or rutting of the base, or the tracking of mud on the primed base or partially completed work.

**405.11 Spreading.** The temperature of the bituminous mixtures delivered shall be according to the following table when a batch, continuous or dryer drum plant for Class I mixes is used. When a dryer drum plant for other than Class I mixes is used, the minimum temperature shall be 90 °C (200 °F.).

	Temperature		
Bituminous Material	Minimum	Maximum	
SC	80 °C (175 °F.)	135 °C (275 °F.)	
MC	Workable	105 °C (225 °F.)	
AC	105 °C (225 °F.)	160 °C (325 °F.)	

The bituminous mixtures shall be placed with a spreading and finishing machine to the typical cross section shown on the plans. On areas where irregularities or unavoidable obstacles make the use of mechanical spreading and finishing equipment impracticable, the mixture shall be spread, raked and luted by hand tools. Where the specified thickness of the finished compacted surface is greater than 50 mm (2 inches), the bituminous mixture shall be spread and compacted in 2 or more layers. When the bituminous mixtures are placed in partial widths, the individual widths of the top layer shall conform to the traffic lanes.

The spreading and finishing machine shall be operated at a speed that will ensure, as near as possible, continuous operation. The operating speed will be approved by the Engineer. A string line shall be used as a guide for the finishing machine in order to maintain uniform edge alignment; if any other method is proposed, it shall meet the approval of the Engineer before being used. Irregularities in the alignment of the outside edges shall be corrected by adding or removing bituminous mixture before the edges are rolled. In spreading the bituminous mixture, care shall be taken to prevent any damage to the prime coat. The bituminous mixture shall be placed away from a transverse joint.

**405.12 Joints.** Contact surfaces of curbs, gutters, manholes, and similar structures shall be painted with a thin uniform coating of Asphalt: RC-70; just before the bituminous mixture is placed against them. The mixture shall be placed uniformly high, so after compaction it will be 6 mm (1/4 inch) above the edges of such structures.

Joints between old and new pavements or between successive days' work shall be made to ensure thorough and continuous bond between the old and new mixtures.

Transverse construction joints in previously laid material may be constructed by cutting the material back for its full depth to expose a fresh surface. Where a wooden header is used at a construction joint, the cutting may be omitted provided the joint conforms to the specified thickness. Before placing the fresh mixture against a cut joint or against old pavement, the contact surface shall be sprayed or painted with a thin, uniform coating of Asphalt: RC-70.

Bituminous material for painting joints shall be considered as included in the cost

of the work and no additional compensation will be allowed.

Surfacing at intersections, alley returns and driveways may be constructed simultaneously with the adjacent areas.

**405.13 Compaction.** After the bituminous mixture has been spread as required, it shall be rolled and compacted thoroughly and uniformly with a three-wheel, tandem, or vibratory roller. Where initial rolling causes undue displacement, hair cracking, or checking of the bituminous mixture, the time of the rolling shall be adjusted as directed by the Engineer.

One three-wheel, tandem or vibratory roller will be required where the average placement at the jobsite is 75 metric tons (85 tons) per hour or less. Two steel wheel rollers either three-wheel, tandem or vibratory, will be required when the average placement at the jobsite is more than 75 metric tons (85 tons) per hour. A self-propelled pneumatic roller may be used in lieu of a steel wheel roller for breakdown rolling followed by a steel wheel roller for finishing when approved by the Engineer.

Rolling of the first lane of bituminous mixture to be placed shall start longitudinally at the edge having the lower elevation and progress to the other edge, overlapping uniformly on successive trips by at least 1/2 the width of the compression wheels. Where laying the bituminous mixture adjacent to a previously placed lane, the first pass of the roller shall be along the longitudinal joint in such a manner that not more than 1/3 the width of the compaction wheel is on the freshly placed mixture; after which the rolling shall proceed from the outside edge toward the longitudinal joint, overlapping uniformly on successive trips by at least 1/2 the width of the compression wheels.

When the roller or rollers as required for plant production cannot make 2 coverages each, of the rolling pattern specified above, an additional roller shall be furnished when requested by the Engineer. Final rolling of the last course of bituminous material shall be accomplished by one passage of the roller along each edge of the pavement. All roller wheels shall be moistened lightly to prevent bituminous material from sticking to the wheels. When the rolling has been completed, and the surface of the bituminous mixture has hardened or cured to the satisfaction of the Engineer, traffic may be allowed upon it.

- **405.14 Surface Tests.** After the bituminous mixture has been compacted, the surface shall be tested for smoothness by means of a 5-m (16-ft.) straightedge placed parallel to the centerline of the pavement, parallel to the grade line in each wheel lane and touching the surface. If the ordinates measured from the surface of the straightedge to the surface of the pavement exceed 10 mm (3/8 inch), the entire area so affected shall be corrected as approved by the Engineer.
- **405.15 Method of Measurement.** Bituminous material for prime coat will be measured according to Section 1009. The unit of measurement will be as shown on the plans.

Bituminous Mixture will be measured in metric tons (tons). The Contractor shall furnish or arrange for the use of scales of a type approved by the Engineer to measure loaded trucks.

Bituminous Mixture produced by a continuous-type mixing plant shall be weighed on approved platform scales furnished by the Contractor. Bituminous Mixture produced by a batch-type mixing plant may be measured by either weighing the mixture on approved platform scales or on the basis of plant weights. If measured on the basis of plant weights, an occasional check shall be made by weighing full truckloads of the mixture on an approved scale at the plant or on an approved commercial scale. If, during the course of construction, it becomes apparent that the weigher on the mixer platform or the weigher at the platform scale is not exercising proper care in weighing the bituminous mixture, the weigher shall be removed at the direction of the Engineer and replaced by a competent and qualified worker. Quantities of materials wasted or disposed of in a manner not called for in the contract will be deducted from the final total measured quantities. The Contractor shall furnish a load ticket (duplicate tickets if required) upon which is recorded the net weight of the bituminous mixture in each truck. The ticket shall have sufficient space for signatures, identification of the mixture, date of delivery, and any other data which the Engineer may require. The Contractor shall submit the load ticket to the Engineer at the work when the truck arrives.

Measurement for payment will not be made for bituminous mixture in excess of 103 percent of the amount specified by the Engineer.

**405.16 Basis of Payment.** This work will be paid for at the contract unit prices per liter (gallon) for BITUMINOUS MATERIALS (PRIME COAT) or per metric ton (ton) for BITUMINOUS MATERIALS (PRIME COAT) and per metric ton (ton) for BITUMINOUS MIXTURE COMPLETE.

If provided as a payment item, the repair and preparation of the base will be measured and paid for as specified in Section 358. If not provided as a payment item, repair and preparation of the base shall be considered as included in the contract unit price for the bituminous surface, and no additional compensation will be allowed.



## SECTION 406. BITUMINOUS CONCRETE BINDER AND SURFACE COURSE CLASS I

**406.01 Description.** This work shall consist of constructing one or more bituminous concrete binder courses and a bituminous concrete surface course on a prepared base.

**406.02 Materials.** Materials shall meet the following requirements of Section 1000 - Materials:

	Item	Article/Section
(a)	Coarse Aggregate	1004.03
		1003.03
		1004.07
(d)	Mineral Filler	1010.04, 1011
		1012.01
	Slaked Quicklime (Note 1)	
		1009

Art. 406.02

Note 1. Slaked quicklime shall conform to the requirements of ASTM C 5.

Note 2. The Contractor shall use any one of the types of bituminous materials listed in the table below. When more than one grade is shown for a particular type, the Engineer reserves the right to specify the grade which shall be used.



Type of Construction	Bituminous Materials
Prime (tack) on Brick, Concrete or Bituminous Bases (Note 3)	SS-1, SS-1h CSS-1, CSS-1h HFE 60, HFE 90 RC-70
Prime on Aggregate Bases	MC-30
Binder and Surface Course Class I, Type 1 Rigid Base Flexible Base Class I, Type 2 Rigid Base Flexible Base RAP Class I, Type 3 Rigid Base Flexible Base RAP Class I, Type 3 Rigid Base Flexible Base RAP	AC 20 AC 10-20 AC 10-20 AC 5-10-20 AC 2.5-5-10-20 AC 5-10 AC 5-10 AC 2.5-5-10
Mixture for Cracks, Joints and Flangeways	AC 10-20

Note 3. When emulsified asphalts are used, they shall be diluted with an equal volume of potable water. HFE emulsions shall be diluted by the manufacturer. The diluted material shall be thoroughly agitated within 24 hours of application and show no separation of water and emulsion. The diluted material shall not be returned to an approved emulsion storage tank.

**406.03 Equipment.** Equipment shall meet the requirements of the following Articles of Section 1100 - Equipment except as modified by the Equipment Definitions of Article 406.16:

	Item	Article/Section
(a)	Self-propelled Pneumatic-Tired Roller	1101.01
(b)	Three-Wheel Roller	1101.01
(c)	Tandem Roller	
(d)	Vibratory Roller	1101.01
(e)	Hot-Mix Plant (Note 1)	1102.01
(f)	Spreading and Finishing Machine	1102.03
(g)	Pressure Distributor	1102.05
(h)	Heating Equipment	1102.07
(i)	Trench Roller	1101.01
(j)	Hot-Mix Surge Bins	1102.01
(k)	Pavement Surface Test Equipment	1101.10(a).

Note 1. When a drier-drum hot-mix plant is used to produce Class I mixtures incorporating RAP material, the plant shall be suitably modified to produce recycled bituminous mixes in a manner approved by the Engineer.

### **CONSTRUCTION REQUIREMENTS**

**406.04 General.** The leveling binder, binder and surface course mixtures shall be placed on a dry base and when weather conditions are suitable. In the event of sudden rain, loading additional trucks shall immediately stop whether it be from the plant or storage bins. Material in transit will be permitted to be laid at the Contractor's risk providing the pavement is free of standing water and the proper temperature of the asphaltic mix is maintained. Approval to unload the trucks in transit shall in no way relax the requirements for quality, density or smoothness of the bituminous mixture being placed.

The leveling binder and binder courses shall be placed only when the temperature in the shade is at least 5 °C (40 °F.) and the forecast is for rising temperatures. The surface course shall be placed only when the air temperature in the shade is at least 8 °C (45 °F.) and the forecast is for rising temperatures.

Mixture use shall be as follows:

Use	Туре	Mixtures
Leveling Binder	1 2 & 3	B or C A, B, or C
Binder Course	1 2 & 3	B A or B
Surface Course	1 & 2 3	C, D or E C

In addition to the requirements listed above, the mixture for leveling binder shall be further modified as follows, depending upon the nominal thickness being placed:



Nominal Leveling Binder Thickness, mm (inch)	Mixture
Under 30 (1 1/4)	C with CA 16
30 (1 1/4)	C with CA 13 or CA 16
40 (1 1/2)	B or any of the above
Over 40 (1 1/2)	A or any of the above

The specific type and mixture to be used for leveling binder, binder course and surface course shall be as shown on the plans.

The Contractor shall furnish samples of the mixture at the place of manufacture or samples cut from the completed work when required by the Engineer for testing purposes. The areas of pavement so removed shall be replaced with new mixture and refinished. Furnishing test samples and replacing the areas with new material shall be considered as included in the cost of the item of construction involved, and no additional compensation will be allowed.

All surfaces shall be cleaned of dirt, debris and loose material prior to placing any bituminous material or bituminous mixture.

**406.05** Keeping Road Open to Traffic. The road shall be kept open to traffic according to Article 701.05(c)(3).

# 406.06 Preparation, Priming and Leveling of Brick, Concrete or Bituminous Bases.

(a) Preparation. When an existing pavement is used as a base, all excess crack filler and bituminous patches which contain an excess of bitumen or which are unstable in hot weather shall be removed. All bitumen shall be removed from expansion joints and cracks more than 40 mm (1 1/2 inches) The Contractor shall perform this work in the most economical manner practicable and as directed by the Engineer. All waste material placed on the shoulders during the pavement cleaning operations shall be removed at the close of each day's work and shall be disposed of outside the limits of the right of way at locations acceptable to the Engineer. This work will be paid for according to Article 109.04.



Prior to placing leveling binder or binder course mixtures for multiple course construction and prior to placing surface course mixture for single course construction, all open cracks and open expansion joints having a width of 15 mm (1/2 inch) or more, expansion joints and cracks that have been cleaned, and street car track flangeways shall be filled completely with Mixture for Cracks, Joints and Flangeways. The mixture shall be hand tamped in place with hand tools. This work shall be completed at least 24 hours prior to placing the first course of bituminous mixture.

(b) Prime Coat. Before placing the bituminous mixture, the base, or base and

gutter shall be cleaned of all dust, dirt, and foreign material and with dry existing conditions, the bituminous material, as specified for prime in Article 406.02, shall be applied uniformly at the rate of 0.2 to 0.5 L/m² (0.05 to 0.10 gal. per sq. yd.). The exact rate to be specified by the Engineer. The temperature in the shade shall be 15 °C (60 °F.) or higher at time of application when emulsified asphalt is used. The bituminous priming material shall be prepared according to Article 403.07. The method of applying the bituminous priming material shall be according to Article 403.09.

The removal and disposal of dust, dirt, and foreign material from the area to be primed shall be included in the cost of the bituminous concrete item involved, and no extra compensation will be allowed for performing this work.

Where the road is to be kept open to traffic, the prime coat (except emulsion type) shall be placed not less than 1 hour in advance of the place of bituminous concrete an no prime coat shall be placed more than 5 days in advance of the placement of bituminous concrete.

Bituminous concrete may be placed over emulsified asphalt primer when the emulsion has broken and all free moisture has evaporated or drained off the surface. When an emulsified asphalt prime is used, the area to be primed shall be limited to that which can be covered with bituminous concrete the same day, unless otherwise permitted by the Engineer.

When directed by the Engineer, the prime coat shall be covered immediately following its application with fine aggregate mechanically spread at a uniform rate of 1 to 2 kg/m² (2 to 4 lbs. per sq. yd.). The pavement shall be primed 1 lane at a time. The lane shall remain closed until the aggregate will not pickup under traffic. On multi-lane pavements, traffic will not be allowed on the primed surface and the traffic control shall be according to Article 701.06(f)(2). In all instances, the priming operation shall be performed in such a manner that a minimum amount of interference will be caused to traffic.

Where the road is closed to thru traffic, non-emulsion type prime may be placed no more than 5 days in advance of the placement of bituminous concrete. The prime coat need not be covered with fine aggregate. At least one lane shall remain unprimed until the prime coat on the adjacent pavement has cured sufficiently and will not pick up under traffic.

(c) Leveling Binder. All depressions of 25 mm (1 inch) or more in the surface of the existing pavement will be filled with leveling binder. The Engineer will specify during construction which method of leveling binder placement shall be used.

Leveling binder placed with a finishing machine will be designated as Leveling Binder (Machine Method).

When placing leveling binder, the finishing machine shall be operated at a speed that shall ensure, as near as possible, continuous operation. The

operating speed of the finishing machine shall be coordinated with the plant production and delivery of material for continuous operation. If the finishing machine is equipped with tamper bars, their use will not be required when the average amount of leveling binder being placed is less than 40 kg/m<sup>2</sup> (70 lbs. per sq. yd.).

Where areas to be leveled are greater than 50 mm (2 inches) in depth, the leveling binder shall be placed and compacted in layers not exceeding a maximum depth of 50 mm (2 inches). The total thickness of leveling binder placed in one day will be limited to 100 mm (4 inches) unless otherwise directed by the Engineer. The leveling binder shall be placed at least 24 hours prior to placing the binder course. Leveling binder shall be compacted according to and meet the density requirements of Article 406.16.

Leveling binder placed other than with a finishing machine will be designated as Leveling Binder (Hand Method). Leveling Binder (Hand Method) shall be compacted with a roller to the satisfaction of the Engineer. Hand tamping will be permitted when approved by the Engineer.

At locations where heavy disintegration and deep spalling exists, the area shall be cleaned of all loose and unsound material with pneumatic tools, or other approved equipment, primed and filled with leveling binder. The cost of removal of all loose and unsound material will be paid for according to Article 109.04. The leveling binder used in these areas will be measured and paid for as specified for Leveling Binder (Hand Method).

## 406.07 Preparation and Priming of Aggregate Bases.

- (a) Preparation. The base shall be prepared according to Section 358.
- (b) Prime Coat. After the base has been prepared, and when in a dry condition, the bituminous material, as specified for prime in Article 406.02, shall be applied uniformly at the rate of 1 to 2 L/m² (0.25 to 0.50 gal. per sq. yd.), the exact rate to be specified by the Engineer. The bituminous priming material shall be prepared according to Article 403.07 and the method of application shall be as specified in Article 403.09.

The bituminous priming material shall be applied to the full width of the base course. The prime coat shall be permitted to cure until the penetration has been approved by the Engineer, but at no time shall the curing period be less than 24 hours. Pools of bituminous material occurring in the depressions shall be broomed or squeegeed over the surrounding surface the same day the prime coat is applied. Immediately after the application of prime coat, it shall be covered with fine aggregate mechanically spread at a uniform rate of 2 to 3 kg/m² (4 to 6 lbs. per sq. yd.) as directed by the Engineer. The base shall be primed 1/2 width at a time. The prime coat on the second half-width shall not be applied until the prime coat on the first half-width has cured so that it will not pickup under traffic. In all instances, the priming operations shall be performed in such a manner that a minimum amount of interference will be caused to traffic.

When the road is closed to traffic, the bituminous prime coat material need not be covered with fine aggregate.

- **406.08 Preparation of Asphalt Cement.** The asphalt cement shall be transferred to the asphalt tanks and brought to a temperature of 120  $^{\circ}$ C to 180  $^{\circ}$ C (250  $^{\circ}$ F. to 350  $^{\circ}$ F.).
- **406.09 Preparation of Mineral Aggregates.** When a blend of 2 or more aggregates, meeting the specifications, is required, it shall be produced by the use of a cold aggregate feeder for each aggregate required. When the proportioning gates of the aggregate feeder are once set for proper blending, they shall be locked or bolted securely and their positions shall not be changed unless directed by the Engineer. If any of the aggregates used in preparing the mixture become intermixed in a bin compartment, the compartment shall be emptied and the intermixed material shall not be used.

The fine and coarse aggregates used in the bituminous mixtures shall be dried and heated in the revolving drier to a temperature of 120 °C to 180 °C (250 °F. to 350 °F.), such temperatures to be determined at the drier discharge. The fine and coarse aggregates for the bituminous mixtures may be fed simultaneously into the same drier. Immediately after heating, the binder course aggregates shall be screened into at least 3 sizes and the surface course aggregates into at least 2 sizes.

At the end of each day's run, the record sheet of the recording pyrometer or thermometer shall be turned over to and shall become a part of the records of the Engineer until the completion of the work.

During the drying process, the moisture content of the aggregate shall be reduced such that the moisture content of the bituminous mixture at time of discharge from the mixer will not exceed 0.5 percent. For certain aggregates such as air-cooled blast furnace slag, novaculite and other highly absorptive aggregates, special handling and treatment such as double drying may be required.

# 406.10 Designs, Mixing Formulas, and Tolerances.

- (a) Designs. The Class I binder and surface course mixtures shall be further classified as Type 1, Type 2, or Type 3 depending on the Marshall property requirements. Class I, Type 1, 2, and 3 Mixture designs shall be established by the Department or by the Contractor at his/her option. The Department will provide or verify no more than 2 mix designs per type of mix, per project, meeting established criteria.
  - (1) Department Designs. The Contractor may request that the Department provide a mix design. The Contractor shall specify the blend of fine aggregate to be used. If the suggested blend does not result in a mix meeting all necessary criteria, the Department will provide a mix design using a fine aggregate blend it determines to be appropriate.

If the Department provided mix design is not satisfactory to the Contractor, he/she may elect to provide his/her own design as outlined in (2).

The Contractor shall be responsible for prompt notification to the District Materials Engineer or local agency of proposed material sources so that sampling, and submittal of material to the Central Laboratory or local agency, may proceed in a timely manner. In no case will the mix design be initiated until the determination of the apparent low bidder.



- (2) Contractor's Designs. The Contractor may provide mix designs for each type of required mixture. Verification of the Contractor's mix design will be according to the Department's current policy Memorandum, "Bituminous Mixture Design Verification Procedure". The mix design shall be developed in a laboratory approved annually by the Department. The laboratory equipment shall meet the requirements set forth in the Department's current Stand Alone Document, "Bituminous Concrete Required Mix Design Laboratory Equipment". In no case will a mix design be verified until determination of the apparent low bidder.
- (b) Mixing Formula. Based on the data from the mixture designs and mixture criteria, mixing formulas will be established for each contract. The formulas will state definite percentages of aggregate on the sieve fractions and a definite percentage of bitumen.
- (c) RAP Designs. At the Contractor's option, Class I, Type 2 and 3, bituminous concrete binder, leveling binder or surface course (Mixture C) may be constructed utilizing RAP material.

When the Contractor chooses the RAP option for Class I, Type 2, the Contractor shall use the job mix formula as determined by the Department. For purposes of establishing the job mix formula, the Contractor shall furnish samples of the RAP coarse aggregate and fine aggregate to the Engineer at least 4 weeks prior to the start of production. The amount of RAP included in the mixture shall not exceed 25% for binder or 15% for surface.

When the Contractor chooses the RAP option for Class I, Type 3 mixtures, the requirements shall be the same as those for Class I, Type 2, except that the Contractor shall inform the Engineer of the desired amounts at the time he provides samples of the mix ingredients. The Engineer reserves the right to adjust the quantities of RAP material contained in the mixture for the purpose of mix design or field production, on the basis of test results.

(d) Determination of Need for Anti-Stripping Additive. The Department will determine during mixture design if an additive is needed in the mix to prevent stripping. The determination will be made on the basis of tests made according to the Department's accepted methods and procedures. To be considered acceptable by the Department as a mixture not susceptible to stripping, the ratio of conditioned to unconditional split tensile strengths (TSR) shall be equal to or greater than 0.75. Mixtures, with or without an additive, with TSR's less than 0.75 will be considered unacceptable.

If it is determined than an additive is required, the additive shall be hydrated

lime, slaked quicklime or a liquid additive, at the Contractor's option. The liquid additive shall be selected from the Department's list of approved additives and may be limited to those which have exhibited satisfactory performance in similar mixes.

Dry hydrated lime shall be added at a rate of 1.0 to 1.5% by weight of total dry aggregate. Slurry shall be added in such quantity as to provide the required amount of hydrated lime solids by weight of total dry aggregate. The exact rate of application for all anti-stripping additives will be determined by the Department. The method of application shall be as specified in Article 406.12.

(e) Field Proportioning Tolerances. For Class I, all mixtures shall closely conform to the formula as determined by hot-bin gradation analysis and will be verified by periodic extraction tests of the final mixture. The right is reserved, at any time during the progress of the work, to make such changes in the mixing formulas, including the percentage of RAP in the mixture, as the Engineer may consider necessary or desirable within the limits of the Specifications. During the progress of the work, the source of materials shall not be changed without prior approval in writing from the Engineer.



After the Engineer has established the job mix formula, the following tolerances will be permitted.

Job Mix Formula Tolerances		
	Binder Course Mixture	Surface Course Mixture
Retained 12.5 mm (1/2 inch) sieve Passing 4.75 mm (No. 4) sieve Passing 236 mm (No. 8) sieve Passing 300 μm (No. 50) sieve Passing 75 μm (No. 200) sieve (Note 1) Bitumen (Note 1)	±6% ±5% ±5% ±44% ±1.5%	- ±5% ±5% ±4% ±1.5% ±0.3%

Note 1: Shall be determined by extraction test or by a calibrated nuclear asphalt gauge.

During production, the ratio of -75  $\mu$ m (-No. 200) sieve material to asphalt shall be not less than 0.6 nor more than 1.2 and the moisture content of the mixture at discharge from the mixer shall not exceed 0.5 percent. If at any time, the ratio of -75  $\mu$ m (-No. 200) sieve material to asphalt or the moisture

content of the mixture falls outside the stated limits, production of mix shall cease. The cause shall be determined and corrective action satisfactory to the Engineer shall be initiated prior to resumption of production.

During production, mixture containing an anti-stripping additive will be tested for stripping by the Department's accepted methods and procedures. If the mixture fails to meet the TSR criteria for acceptance, no further mixture will be accepted until the Contractor takes such action as is necessary to furnish a mixture meeting the criteria.

**406.11 Preparation of Mixture for Cracks, Joints and Flangeways.** When the mixture is prepared in a batch-type mixing plant, the heated aggregate and the asphalt cement shall be measured separately and accurately by weight or by volume. The heated aggregate and asphalt cement shall be mixed in a pug mill mixer. When the aggregate is in the mixer, the asphalt cement shall be added and mixing continued until a homogeneous mixture is produced in which all particles of aggregate are coated uniformly. The mixing time will be determined by the Engineer.

When the mixture is prepared in a continuous-type mixing plant, the heated aggregate and asphalt cement shall be measured separately and accurately by volume. The heated aggregate and asphalt cement shall be mixed in the pug mill mixer for a period of time necessary to produce a homogeneous mixture in which all particles of aggregate are coated uniformly. The mixing time will be determined by the Engineer.

When the mixture is prepared in a drier drum plant, the heated aggregate and asphalt shall be accurately proportioned and mixed in the drier drum plant.

For all types of plants, the ingredients shall be combined in such proportions as to produce a mixture conforming to the following composition limits by weight:

Fine Aggregate (FA 1, FA 2 or FA 3)	) 93-	-96%
Bitumen		4-7%

With the permission of the Engineer, an approved cold-lay sand asphalt mixture may be used in lieu of the above mixture.

#### 406.12 Preparation of Bituminous Mixtures.

#### (a) Batch-Type Plant.

When the bituminous mixture is prepared in a batch-type mixing plant, the heated aggregates, the mineral filler, and the asphalt cement shall be measured separately and accurately by weight or by volume. The heated aggregates and mineral filler shall be mixed in the pug mill mixer for a period of not less than 10 seconds. The asphalt cement shall then be added and the mixing continued. The time required to add the asphalt cement shall be not more than 15 seconds. The total time required for adding the asphalt cement and completing the wet mixing period shall be not less than 35 seconds, or longer if necessary to produce a homogeneous mixture in which all particles of aggregate are coated uniformly. When the RAP option is used, the mix time for a batch type plant may vary in relation to the nature of the aggregate. The total mixing time shall be a minimum

of 45 seconds consisting of dry and wet mixing. The times of dry and wet mixing shall be set by the Engineer. The same size batch weights shall be used in the production of bituminous mixtures, unless permission to change is granted in writing by the Engineer.

# (b) Continuous-Type Plant.

When the bituminous mixture is prepared in a continuous-type mixing plant, the heated aggregates, mineral filler and asphalt cement shall be measured separately and accurately by volume. The heated aggregates, mineral filler and asphalt cement shall be mixed in the pug mill mixer for a period of not less than 45 seconds, or longer if necessary to produce a homogeneous mixture in which all particles of aggregate are coated uniformly.

### (c) Drier Drum Plant.

When the bituminous mixture is prepared in a drier drum plant, the heated aggregates, mineral filler and asphalt shall be proportioned by electronic proportioning equipment and mixed until a homogeneous, uniformly coated, mix is produced. If the Engineer ascertains that proper mixing is not being obtained, adjustments shall be made in the plant operation (production rate, drier drum slope, etc.) to assure that these conditions are met. When the RAP option is used in a drier drum plant, mixing shall be continued until a homogeneous, uniformly coated mix is obtained. If a question as to the degree of coating should arise, AASHTO T 195 shall be used.

# (d) All Types of Plants.

For all types of plants, the ingredients shall be heated and combined in such a manner as to produce a bituminous mixture which when discharged from the plant will in general vary not more than 10 °C (20 °F.) from the temperature set by the Engineer; in all cases, the temperature shall not be more than 180 °C (350 °F.) or less than 120 °C (250 °F.). Wide variations in the mixture temperature of successive loads may be cause for rejection of the mix.

Whenever a hot-mix plant is being used to produce Class I, Type 1 mixtures and other types of mixtures, all hot bins shall be emptied and all hot and cold aggregate in the drier and on all collector conveyors shall be removed before the production of Class I, Type 1, mixtures may be started or resumed once the Type 1 mixture has been interrupted for the purpose of producing a different mixture.

When an anti-stripping additive is required and a liquid additive is used, it shall be added to the asphalt by means of an approved in-line blender system located between the plant supply tank and distribution on the heated aggregate. The in-line blender system shall be installed in such a location that the liquid additive cannot recirculate and contaminate the supply tank. The in-line blender system shall be capable of delivering a consistent and controllable stream of material to the asphalt under all operating weather conditions and shall be capable of controlling the introduction of additive into the asphalt within  $\pm 10$  percent of the amount specified or required. The Contractor shall use methods and procedures for handling and storage of

the additive which meet manufacturer's safety recommendations.

When lime is used as the anti-stripping additive, a separate bin or tank and feeder system shall be provided to store and accurately proportion the lime onto the aggregate in either dry or slurry form. The lime and aggregate shall be mixed by a power driven pugmill prior to entering the drier. In the event lime is added in dry form, the aggregate shall be dampened sufficiently to provide a uniform coating of lime. The feeder system shall be controlled by a proportioning device which shall provide an accuracy to within ±10 percent of the specified amount of lime solids. The proportioning device shall have a convenient and accurate means of calibration and shall be interlocked with the aggregate feed or weight system so as to maintain the required proportion. A flow indicator or sensor shall be provided and interlocked with the plant controls such that the production of the mixture will be interrupted if there is a stoppage of the lime feed. The stockpiling of lime treated aggregate will not be permitted. The methods of introducing and mixing the anti-stripping additive and aggregate shall be subject to approval by the Engineer prior to beginning production.

#### 406.13 Mixture Criteria.

(a) Mixture Composition. For Class I, Type 1, 2, and 3, the ingredients of the bituminous mixture shall be combined in such proportions as to produce a mixture conforming to the composition limits by weight. The job-mix formula selected shall produce a mixture falling within the following limits:

<u>Sieve</u>	Binder <u>Mixture A</u>	Binder <u>Mixture B</u>	Surface Mixture C, D, or E
37.5 mm (1 1/2")	100		
25 mm (1")	90 - 100		100
19 mm (3/4")		82 - 100	100
12.5 mm (1/2")	45 - 75	50 - 85	90 - 100
9.5 mm (3/8") <sup>^</sup>			66 - 100
4.75 mm (#4)	24 - 42	24 - 50	24 - 65
2.36 mm (#8)	16 - 31	16 - 36	16 - 48
1.18 mm (#16)	10 - 22	10 - 25	10 - 32
300 μm (#50)	4 - 12	4 - 12	4 - 15
150 μm (#100)	3 - 9	3 - 9	3 - 10
75 μm (#200)	2 - 6	2 - 6	2 - 6
Bitumen(%) 2/	3 - 9	3 - 9	3 - 9

1/ - Based on percent of total aggregate weight.

<sup>2/ -</sup> Based on percent of total mixture weight.

One of the above gradations shall be used for leveling binder according to the requirements of Article 406.04.



The mixture composition shall not exceed 40% passing the 4.75 mm (No. 4) seive for A&B binder courses and 40% passing the 2.36 mm (No. 8) seive for C, D, &E surface courses. The 40% maximum limit for surface mixtures may be exceeded by 2% for crushed slag coarse aggregate Type 1 mixtures only.

- (b) Filler/Asphalt Ratio for Class I, Type 1, 2, and 3. The ratio of material passing the 75  $\mu$ m (No. 200) sieve to asphalt cement shall not exceed 1.0 for mixture design (based on total weight of mixture).
- (c) Fine Aggregate Blend Requirement For Class I, Type 1. At least 50 percent of the required fine aggregate fraction shall consist of either stone sand, slag sand or steel slag sand meeting the FA 20 gradation.



- (d) Marshall Properties.
  - (1) For Class I, Type 1. The procedure used for Class I, Type 1 shall be 75-blow Marshall mix design.

		Voids In The Mineral			
	<u>Mixture</u>	Aggregate (min.)	Air <u>Voids (%)</u>	Minimum Stability kN (lbs.)	Flow <u>Range</u> 0.25m (0.01 inch)
	B Binder C, D, or E Sur C, D or E Surf		3.5-5.0 3.5-4.5	8.8(2000) 8.8(2000)	8 - 16 8 - 16
L	(Full-Depth)	15.0	3.5-4.5	8.8(2000)	8 - 16

(2) For Class I, Type 2. The procedure used for Class I, Type 2 shall be 50-blow Marshall mix design.

	Voids In The Mineral			
<u>Mixture</u>	Aggregate (min.)	Air <u>Voids (%)</u>		Flow <u>Range</u> 0.25 mm (0.01 inch)
A & B Binder C, D or E Surf C, D, or E Sur (Full-Depth)		3.5-4.5 3.5-4.5	7.5(1700) 7.5(1700) 7.5(1700)	8 - 16 8 - 16 8 - 16

(3) For Class I, Type 3. The procedure used for Class I, Type 3 shall be 50-blow Marshall mix design.

Mixture	Voids In The Mineral Aggregate (min.)	Air <u>Voids (%)</u>		Flow <u>Range</u> 0.25 mm (0.01 inch)
A & B Binder C Surface Mixture	12 13	2-4 2-4	6.6 (1500) 6.6 (1500)	8-16 8-16

- **406.14 Transportation.** Vehicles used in transporting the bituminous mixtures shall have clean and tight beds. The beds shall be sprayed with asphalt release agents which have been tested and approved for use by the Department. After spraying, the bed of the vehicle shall be in a completely raised position and it shall remain in this position until all excess asphalt release agent has been drained. When the air temperature is below 15 °C (60 °F.), the bed, including the end, endgate, sides and bottom shall be insulated with fiberboard, plywood or other approved insulating material and shall have a thickness of not less than 20 mm (3/4 inch). When the insulation is placed inside the bed, the insulation shall be covered with sheet steel approved by the Engineer. Each vehicle shall be equipped with a cover of canvas or other suitable material meeting the approval of the Engineer which shall be used if any one of the following conditions are present:
  - (a) Ambient air temperature is below 15 °C (60 °F.).
  - (b) The weather is inclement.
  - (c) The temperature of the bituminous mixture immediately behind the paver screed is below 120 °C (250 °F.).

The cover shall extend down over the sides and ends of the bed for a distance of approximately 300 mm (12 inches) and shall be fastened securely. The covering shall be rolled back before the load is dumped into the finishing machine. Unless artificial light satisfactory to the Engineer is provided, no bituminous mixture which cannot be placed and compacted during daylight shall be delivered to the work.

## 406.15 Placing.

(a) General. The bituminous mixtures shall be delivered at a temperature of 120 °C - 175 °C (250 °F. - 350 °F.). The bituminous mixture shall be placed with a spreading and finishing machine to the typical section and grade shown on the plans or as established by the Engineer. On areas where irregularities, inaccessibility, or unavoidable objects make the use of mechanical spreading and finishing impractical, as determined by the Engineer, the mixture may be spread, raked and luted by hand.

When placing bituminous mixtures within a minimum of 60 m (200 ft.) from a bridge abutment, the automatic electronic grade control on the paver shall be operated from a preset grade control stringline. At all other locations, a preset grade control stringline or a grade reference device traveling on the adjacent pavement surface shall be used. When traffic interference or

sharp curves make the minimum 9 m (30 ft.) device impractical, the grade reference device may be shortened to no less than 3 m (10 ft.) as directed by the Engineer.

Placing the bituminous mixtures shall be away from a transverse joint. The binder course shall be kept clean until covered with the surface course. Any foreign material on the surface of the binder course shall be removed to the satisfaction of the Engineer before the surface course is placed. Intermingling of different mixes at any one paver will not be permitted.

Unless prohibited by stage construction, any bituminous concrete course lift shall be complete before construction of the subsequent lift. The longitudinal joint in all lifts shall be at the centerline of the pavement if the roadway comprises 2 lanes in width or at lane width if the roadway is more than 2 lanes in width.

When stage construction prohibits the total completion of a particular lift, the longitudinal joint in one lift shall be offset from the longitudinal joint in the preceding lift by not less than 75 mm (3 inches). The longitudinal joint in the surface course shall be at the centerline of the pavement if the roadway comprises 2 lanes in width or at lane width if the roadway is more than 2 lanes in width.

The operating speed of the paver shall not exceed that speed which is necessary to produce a uniformally spread and struck off mat having a smooth texture without tearing or segregation. The paver speed shall be mated with the required roller speed and shall not exceed that which coincides with the average rate of delivery of bituminous material to the paver to provide, as nearly as possible, continuous operation of the paver. In no case shall the speed of the paver exceed 15 m (50 ft.) per minute.

A stringline shall be used as a guide for the finishing machine in order to maintain a uniform edge alignment; if any other method is proposed, it shall meet the approval of the Engineer before being used. Irregularities in the alignment of the outside edges and along the longitudinal joint shall be corrected by adding or removing bituminous mixtures before the edges are rolled. Excess bituminous mixtures deposited on the existing base, binder course or surface course outside the limits of the lane being laid shall be removed immediately and disposed of as directed by the Engineer.

A straightedge at least 1 m (4 ft.) in length and equipped with a carpenter's level shall be available at the spreading and finishing machine to check the surface of the bituminous mixture for transverse slope and longitudinal surface variations.

(b) Test strip, for Class I, Type 1 and 2. At the start of both binder and surface course placement, and at other times as required by the Engineer, the Contractor shall construct a test strip for the purpose of evaluating the properties of the bituminous mixture. The test strip shall consist of no more than 180 metric tons (200 tons) of bituminous mixture placed at a paver speed of no more than 8 m (25 ft.) per minute.

Within the test strip, 2 or more growth curves will be constructed using a vibratory roller. The mixing and placement shall stop until the test strip has been evaluated. If the test strip results are satisfactory, the mixing and placement may be resumed and a rolling pattern established. If the test strip results are unsatisfactory, the Engineer will make appropriate adjustments and another test strip shall be constructed. This procedure will be followed until a satisfactory test strip is obtained. The test strip requirement may be waived by the Engineer.

(c) Rolling Pattern for Class I, Type 1 and 2. Once the test strip(s) requirements have been satisfied, an appropriate rolling pattern shall be established for both binder and surface courses. The purpose of the rolling pattern is to determine the types of rollers, number of passes, roller speed, paver speed, and sequence of operations necessary to meet the density requirements specified herein. Once a satisfactory rolling pattern is established, it shall be continued for the balance of the work unless otherwise changed by the Engineer.

## 406.16 Compaction.

(a) Rolling. Immediately after each lift of level binder, binder, or surface course mixture is placed, each lift shall be compacted with equipment meeting the requirements listed in the following Table 1.

Art. 406.16

TABLE 1. MINIMUM ROLLER REQUIREMENTS FOR BITUMINOUS CONCRETE, CLASS I					SS I
	BREAKDOWN (One of the following)	INTERMEDIAT	E FINAL (One or more of the following)	MINIMUM ADDITIONAL ROLLER REQUIREMENTS	DENSITY REQUIREMENT
Level Binder < 40 mm (1 1/2")	Р		T <sub>F</sub> ,V <sub>S</sub> , 3W,P,T <sub>B</sub>		To satisfaction of Engineer
Class I, Type 1 and 2 Level Binder (other than above) Binder 1/	3W,P,T <sub>B,</sub> V <sub>D</sub>	Р	T <sub>B</sub> ,T <sub>F</sub> ,V <sub>S</sub> Sui	If the required density is not obtained, one of the following additional rollers face 1/  B, VD	As specified 406.16(b)
Bridge Decks 2/	Т <sub>В</sub>		T <sub>F</sub>		As specified
Class I, Type 3  Level Binder (other than above) Binder 1/ Surface 1/	3W,P,T <sub>B,</sub> V <sub>D</sub>	Р	$T_{B_i}$ $T_{F_i}$ $V_{S}$		To satisfaction of the Engineer

Art. 406.16

- 1/ If the average delivery at the job site is 75 metric ton/hr. (85 ton/hr.) or less, any roller combination may be used provided it includes a steel wheeled roller and the required density and smoothness is obtained.
- 2/ One T<sub>B</sub> may be used for both Breakdown and Final rolling on bridge decks 90 m (300 ft.) or less in length, except when the air temperature is less than 15 °C (60 °F.).



#### **EQUIPMENT DEFINITION**

- V<sub>S</sub> Vibratory roller, static mode, minimum 2.2 kg/mm (125 lbs./inch) of roller width. Max. speed = 5 km/h (3 mph) = 80 m/min (264'/min.).
  - If the vibratory roller does not eliminate roller marks, its use shall be discontinued and a tandem roller adequately ballasted to remove roller marks shall be used.
- V<sub>D</sub> Vibratory roller, dynamic mode, operated at a speed to produce not less than 30 impacts/m (10 impacts/ft.).
  - Pneumatic-tired roller, max. speed 5.5 km/h (3 1/2 mph) = 92 m/min (308 ft./min.) Minimum tire pressure 550 kPa (80 psi).
    - Pneumatic-tired roller shall be equipped with heat retention shields. The self-propelled pneumatic-tired roller shall develop a compression of not less than 50 N (300 lbs.) nor more than 90 N (500 lbs.) per mm (per inch) of width of the tire tread in contact with the bituminous surface.
- T<sub>B</sub> Tandem roller for breakdown rolling, 7 to 11 metric tons (8 to 12 tons), 40 to 70 N/mm (250 to 400 lbs./inch) of roller width, max. speed 5.5 km/h = 92 m/min (3 1/2 mph = 308 ft./min.)
- T<sub>F</sub> Tandem roller for final rolling, 35 to 70 N/mm (200 to 400 lbs./inch) of roller width with minimum roller width of 1.25 m (50 inches). Ballast shall be increased if roller marks are not eliminated. Ballast shall be decreased if mat shoves or distorts.
- 3W Three wheel roller, max. speed 5 km/h = 80m/min (3 mph = 264'/min.), 50 N to 70 N/mm (300 to 400 lbs./inch) of roller width. The three-wheel roller shall weigh 9 to 11 metric tons (10 to 12 tons).

When initial rolling causes undue displacement, haircracking or checking in either the binder course or the surface course, the time of rolling shall be adjusted by the Engineer to correct these conditions.

Rolling of the first lane of binder and surface course shall start longitudinally at the edge having the lower elevation and progress to the other edge, overlapping on successive trips to obtain uniform coverage. The roller shall not pass over an unprotected edge of the freshly laid bituminous mixture, unless directed by the Engineer. When directed by the Engineer, the edge shall be rolled with a pneumatic tired roller. When laying the bituminous mixture adjacent to a previously placed lane, the first pass of the roller shall be along the longitudinal joint on the fresh mixture with the compression wheel not more than 150 mm (6 inches) from the joint. The second pass of the roller shall overlap the longitudinal joint not more than 300 mm (12 inches) on the previously placed lane after which the rolling shall proceed from the low side of the transverse slope to the high side, overlapping uniformly. Each stop shall be regulated to prevent trapping of water on the The steel-wheeled rollers shall be operated with the rolled surface. compression wheels toward the direction of paving.

The speed of the roller at all times shall be slow enough to avoid displacement of the bituminous mixture. If displacement occurs, it shall be corrected at once by raking and applying a fresh bituminous mixture where required. To prevent adhesion of the bituminous mixture to the roller, the wheels shall be kept properly moistened without an excess of water.

Rolling of the binder and surface courses shall be continued until all roller marks are eliminated and the bituminous mixture is satisfactorily compacted.

When required by the Engineer, the surface course shall be rolled diagonally in 2 directions with a tandem roller, the second rolling crossing the lines of the first, and, if the width of the pavement permits, it shall also be rolled at right angles to the centerline.

In all places inaccessible to the rollers, such as locations adjacent to curbs, gutter, headers, manholes and similar structures, the required compaction shall be secured with tampers.

Any bituminous mixture that becomes loose, broken, mixed with foreign material or is in any way defective shall be removed and replaced with fresh hot mixture and compacted to conform to the surrounding area.

- (b) Density. The density of the finished binder or surface course shall be measured either by nuclear test methods or from cores obtained by the Contractor at random locations identified by the Engineer.
  - (1) Compaction.
    - a. Class I, Type 1. Bituminous concrete binder, leveling binder [40 mm (1 1/2 inches) or greater], or surface course shall be compacted to an average density of 92.0 to 96.0 percent of the theoretical maximum density as determined by Illinois Modified

AASHTO T 209. No individual test shall be below 91.0 percent. The average shall be based on tests representing one day's production. A minimum of 2 tests shall be conducted for a day's production.

- b. Class I, Type 2. Bituminous concrete binder, leveling binder (40 mm (1 1/2") or greater), or surface course shall be compacted to an average density of 93 to 97 percent of the maximum theoretical density as determined by Illinois Modified AASHTO T 209. No individual test shall be below 91 percent. The average shall be based on tests representing a day's production. A minimum of 2 tests shall be conducted for a day's production.
- (2) Coring. Coring shall be conducted using procedures and equipment that shall provide undamaged, undistorted cores of a diameter of no less than 90 mm (3 5/8 inches).

The holes caused by the removal of the cores shall be refilled immediately with a bituminous material meeting these specifications, compacted and finished to the satisfaction of the Engineer.

The Contractor shall promptly transport obtained cores to the plant laboratory for density determination.

Determination of bulk specific gravity of cores will be performed by the Engineer using procedures specified in IL 166-86 or, if applicable, IL 275-86.

No less than 4 nor more than 20 cores per day will be required by the Engineer for the purpose of acceptance and/or comparison with nuclear gage density measurements.

The cost of this work will not be paid for separately, but shall be considered as included in the unit price bid for the bituminous concrete item involved.

(3) Nuclear Methods. When density is measured by nuclear methods, a test shall consist of the average of 5 one minute determinations located across the width of a 3.6 to 4.3 m (12 to 14 ft.) paving lane.

Density tests, either core or nuclear, shall be performed at randomly selected locations in maximum 800 m (1/2 mile) intervals for lifts 75 mm (3 inches) or less in thickness. For lifts thicker than 75 mm (3 inches), a test shall be performed in maximum 400 m (1/4 mile) intervals. Nuclear testing of lifts 100 mm (4 inches) or thicker shall be performed in the direct transmission mode.

If density is not within the specified limits, mixture production and laydown shall be evaluated and corrective action taken prior to continuing the next day. Additional compactive effort may be required through modifying the rolling pattern or adding rollers. All changes to the laydown and production operation shall be at the Contractor's expense and approved by the Engineer. Density within the limits shall be achieved without excess aggregate breakage, the formation of hairline cracks, separation of the lift from the underlying layer, or other damage.

**406.17 Joints.** Joints between old and new pavements or between successive days' work shall be made so as to ensure thorough and continuous bond between the old and new mixtures.

Transverse construction joints in previously laid material may be constructed by cutting the material back for its full depth so as to expose a fresh surface. Where a wooden header is used at a construction joint, the cutting may be omitted provided the joint conforms to the specified thickness.

**406.18 Butt Joints.** When butt joints are to be constructed under traffic, the Contractor shall provide and maintain temporary bituminous ramps at both upstream and downstream ends of the area removed. The Contractor shall have sufficient bituminous material meeting the approval of the Engineer at the worksite to construct the ramps before beginning the pavement surface removal. Surface removal will be according to Section 440. Cold-milled bituminous tailings will not be acceptable for ramps. The temporary ramps shall be constructed immediately upon completion of the removal operation and the area between shall be leveled and filled as necessary. Ramps shall have a minimum taper rate of 1:40 (V:H). The temporary ramps shall be removed prior to placing the proposed surface course.

The Contractor shall not begin construction of butt joints prior to beginning general operations on the project. If work is suspended for the winter season prior to completion of surface course construction, precut butt joints shall be filled to the elevation of the existing pavement surface with compacted bituminous concrete surface course or binder course.

**406.19 Approaches, Intersections and Entrances.** The thickness of the bituminous surface at the ends of the proposed resurfacing and adjacent to railroad grade crossings shall be diminished uniformly to a featheredge at a rate of 1:240 (V:H). At paved intersections, the bituminous resurfacing shall be feathered out in a distance of 3 m (10 ft.), unless otherwise directed by the Engineer. At these locations, the thickness of the surface course shown on the plans shall be maintained to a point where the binder course has been reduced to 25 mm (1 inch) in thickness. Beyond this point, surface course only shall be used. At these locations where the bituminous surface is diminished uniformly to a featheredge, the last 1.5 m (5 ft.) shall receive an additional application of prime as specified in Article 406.02, just prior to placing the bituminous mixture. This prime will not be paid for separately but shall be included in the contract unit bid price for Bituminous Concrete Surface Course.

Unpaved intersections and entrances shall be constructed as shown on the plans or designated by the Engineer. The existing surface shall be bladed, shaped and compacted before the prime is placed. The prime coat at unpaved intersections shall be as specified in Article 406.02, and applied at the rate of 1 to 2 L/m² (0.25 to 0.50 gal. per sq. yd.), unless otherwise directed by the Engineer. The cost of this work will not be paid for separately but shall be included in the contract unit bid price for Bituminous Concrete Surface Course.

The shoulder aggregate shall be omitted at intersections, when directed by the Engineer, and resurfacing material shall be placed as specified for entrances.

**406.20 Multi-Lane Pavement Resurfacing.** For multi-lane pavement resurfacing, the layer(s) of binder course shall be placed and compacted prior to start of placement of the surface course mixture. When bituminous shoulder resurfacing



is not being constructed simultaneously with the mainline pavement, a bituminous concrete wedge at least 1 m (3 ft.) wide shall be placed on the shoulder simultaneously with binder placement on the mainline pavement, according to the wide shall be placed on the shoulder simultaneously with binder placement on the mainline pavement. The wedge shall be constructed according to the details shown on the plans or as directed by the Engineer. The cost of this wedge shall be included in the cost of bituminous shoulders as specified in Section 482.

**406.21 Surface Tests.** The completed surface course will be tested for smoothness in the wheel paths with a 5-m (16-ft.) straightedge. Surface variations of the mainline pavement shall not exceed 5 mm (3/16 inch). Mainline pavement is defined as all pavement other than ramps which will be posted for speeds of 70 km/h (40 mph) or less, acceleration and deceleration lanes, crossovers, side street returns, and other miscellaneous pavement surfaces as determined by the Engineer. In all areas other than mainline pavement, surface variations shall not exceed 10 mm (3/8 inch).

The smoothness test will not be performed on binder courses, but the Engineer reserves the right to require corrective measures when obvious surface variations are evident.

For each variation in the surface course that exceeds the maximum permissible specified above but is less than 20 mm (3/4 inch), a deduction will be made in the tonnage of surface course mixture measured for payment as specified in the following table:



Binder and/or Surface Course Plan Thickness, mm	Surface Course Mixture Deduction Per Variation, metric ton	
(Existing Surfa	ace Not Reprofiled)	
70 or more Less than 70	2 1	
(Existing Surface Reprofiled)		
All	2	

In all cases where the variation in surface course equals or exceeds 20 mm (3/4 inch), the entire area affected shall be removed and replaced with fresh surface course mixture at the entire expense of the Contractor.

The Contractor shall furnish a 5-m (16-ft.) straightedge and shall provide for its jobsite transportation. The cost of furnishing the straightedge and providing for its jobsite transportation shall be considered as included in the unit price bid for the various items of bituminous concrete surface course involved, and no additional compensation will be allowed.

**406.22 Protection of Pavement.** The Contractor shall protect all sections of newly compacted binder and surface courses from traffic until they have hardened to the satisfaction of the Engineer.

#### 406.23 Method of Measurement.

- (a) Contract Quantities. The requirement for the use of contract quantities shall be according to 202.07(a).
- (b) Measured Quantities. Bituminous priming material will be measured for payment as specified in Section 1009. Water added to emulsified asphalt as specified in Article 406.02 will be included in the quantities measured for payment.

Aggregate for covering prime coat will be measured for payment in metric tons (tons). The aggregate will be weighed on platform scales meeting the approval of the Engineer.

Mixture for cracks, joints and flangeways, leveling binder (machine method), leveling binder (hand method), binder course, and surface course mixtures will be measured for payment in metric tons (tons) on approved platform scales, surge bin scales or surge bin hopper scales equipped with automatic printers as specified in Article 1102.01(a)(13). Bituminous mixtures produced by a batch-type mixing plant may be measured by batch weights only when surge or storage bins are not used. An occasional check to verify the accuracy of the batch weights or automatic printers, will be made by weighing full truck loads of the bituminous mixtures on an approved platform scale at the plant or on a commercial scale approved by the Engineer. If it becomes apparent that the batch weights or automatic printers are not accurate in measuring the bituminous mixture, the scales and/or printers shall be repaired immediately. Quantities of materials wasted or disposed of in a manner not called for in the contract will be deducted from the final total measured quantities. Contractor shall furnish a load ticket (duplicate tickets if required) upon which is recorded the net weight of the bituminous mixture in each truck, as specified in Article 1102.01(a)(13). In addition, the load ticket shall have sufficient space for signatures, identification of the bituminous mixture, date of delivery, and any other data which the Engineer may require. The Contractor shall submit the load ticket to the Engineer at the work site when the truck arrives.

Measurement for payment will not be made for any bituminous concrete mixture in excess of 103 percent of the quantity specified by the Engineer.

Surface removal for butt joints will be measured for payment in place and the area computed in square meters (square yards).

Temporary ramps will be measured for payment in place and area computed in square meters (square yards).

When the option of Class I, Type 1 and 2 mixture on shoulders is used, and shoulders at 1.8 m (6 ft.) or less in width are placed simultaneously with the traffic lane as specified in Section 482, the quantity of bituminous mixture placed on the traffic lane will be limited to a calculated tonnage based upon actual mat width and length, plan thickness or a revised thickness authorized by the Engineer, and design mix weight per millimeter (inch) of thickness. The difference between the total actual tonnage placed and the calculated tonnage used on the traffic lane will be measured and paid for as Bituminous Shoulders according to Section 482.

When a bituminous concrete wedge is placed simultaneously with the binder course as specified in Article 406.20, the quantity of binder course placed on the

traffic lane will be limited to 103 percent of the quantity specified by the Engineer. The difference between the total actual tonnage placed and 103 percent of the tonnage specified by the Engineer will be measured and paid for as Bituminous Shoulders according to Section 482.

**406.24 Basis of Payment.** Prime Coat will be paid for at the contract unit price per liter (gallon) or per metric ton (ton) for BITUMINOUS MATERIALS (PRIME COAT), and per metric ton (ton) for AGGREGATE (PRIME COAT).

The bituminous concrete surfacing will be paid for at the contract unit price per metric ton (ton) for MIXTURE FOR CRACKS, JOINTS AND FLANGEWAYS; at the contract unit price per metric ton (ton) for LEVELING BINDER (MACHINE METHOD), LEVELING BINDER (HAND METHOD) and BITUMINOUS CONCRETE BINDER COURSE, of the type specified; at the contract unit price per metric ton (ton) for LEVELING BINDER (MACHINE METHOD) and BITUMINOUS CONCRETE BINDER COURSE, of the mixture and type specified; and at the contract unit price per metric ton (ton) for BITUMINOUS CONCRETE SURFACE COURSE, CLASS I, of the mixture and type specified.



Surface removal for butt joints will be paid for at the contract unit price per square meter (square yard) for BITUMINOUS SURFACE REMOVAL - BUTT JOINT and PORTLAND CEMENT CONCRETE SURFACE REMOVAL - BUTT JOINT which price will include all the necessary equipment and labor to complete and maintain ramps.

Temporary ramps will be paid for at the contract unit price per square meter (square yard) for TEMPORARY RAMP.

Test strips constructed for the purpose of evaluating the properties of a bituminous mixture will be paid for at the contract unit price each for CONSTRUCTING TEST STRIP. A test strip will be considered as having been constructed when a satisfactory test strip has been obtained for a specific bituminous mixture. If the Contractor requests and is granted approval for a mix design change, he/she shall construct a test strip for the new mix design at his/her own expense, and no additional compensation will be allowed.

If an anti-stripping additive is required for any bituminous mixture, the cost of the additive will be paid for according to Article 109.04. The cost incurred in introducing the additive into the mixture will not be paid for separately, but shall be considered as included in the contract unit price bid for the bituminous concrete item involved. No additional compensation will be awarded to the Contractor because of reduced production rates associated with the addition of the additive.



If provided as a payment item, the preparation of base will be measured and paid for as specified in Section 358. If not provided as a payment item, the cost of preparation of the base shall be considered as included in the contract unit prices for the various bituminous concrete items involved, and no additional compensation will be allowed.

#### SECTION 407. BITUMINOUS CONCRETE PAVEMENT (FULL-DEPTH)

**407.01 Description.** This work shall consist of constructing a full-depth bituminous concrete pavement structure comprised of one or more bituminous

concrete binder courses and a bituminous concrete surface course on a prepared subgrade.

- **407.02 Materials.** Materials shall meet the requirements of Article 406.02 except that if a light fog prime is required by the Engineer, between bituminous concrete lifts, the bituminous material for prime shall be RC-70.
- **407.03 Equipment.** Equipment shall meet the requirements of Article 406.03 and Article 1101.10.

#### CONSTRUCTION REQUIREMENTS

- **407.04 General.** Except as specified, Bituminous Concrete Pavement (Full-Depth) shall be constructed according to the applicable portions of Section 406, with binder and surface course types corresponding to the full-depth pavement type shown on the plans.
- **407.05 Subgrade.** The subgrade shall be prepared according to Section 301 except Articles 301.04 and 301.05 will not apply.
- **407.06 Placing.** Placing of bituminous mixtures shall be according to Article 406.15 and the following:

The compacted thickness of the initial lift of binder course shall be a minimum 100 mm (4 inches). Succeeding lifts shall be not more than 100 mm (4 inches) thick when compacted except that the top lift of binder shall have a minimum 50-mm (2-inch) thick compacted layer. If a vibrating roller is used for breakdown, the compacted lift thickness of lower layers of binder may be increased to 150 mm (6 inches), provided the required density is obtained.

Unless prohibited by stage construction or other restricted access, any bituminous concrete course lift shall be complete before construction of the subsequent lift. The longitudinal joint in all lifts shall be at the centerline of the pavement if the roadway comprises 2 lanes in width or at lane width if the roadway is more than 2 lanes in width.

When stage construction prohibits the total completion of a particular lift, the longitudinal joint in one lift shall be offset from the longitudinal joint in the preceding lift by not less than 75 mm (3 inches). The longitudinal joint in the surface course shall be at the centerline of the pavement if the roadway comprises 2 lanes in width or at lane width if the roadway is more than 2 lanes in width.

Prior to placing the initial lift of the bituminous concrete binder course, all trimmings and other loose material shall be removed from the prepared subgrade to prevent blowing and dusting of bituminous concrete layers.

Each compacted lift of bituminous concrete mixture shall be thoroughly clean of all dirt, dust, and foreign material to the satisfaction of the Engineer before the next lift is placed. All cleaning operations such as blowing, power brooming, washing, blading or milling necessary to thoroughly clean the bituminous surfaces shall be at the Contractor's expense.

When directed by the Engineer, a light fog tack coat of RC-70 shall be applied between lifts of bituminous concrete material at a rate of approximately 0.1 L/m<sup>2</sup> (0.02 gal. per sq. yd.).



**407.07 Pipe Underdrains.** If pipe underdrains are to be constructed along the edges of the full-depth pavement, construction of the pipe underdrains shall not be started until at least 250 mm (10 inches) of bituminous concrete binder course or the entire thickness of the full-depth pavement, whichever is the lesser, is in place. Material excavated from the trench for the underdrain shall not be deposited or windrowed on any portion of the full-depth pavement.

**407.08** Hauling on the Partially Completed Full-Depth Pavement. Trucks will be permitted on partially completed segments of full-depth bituminous concrete pavement only to deliver bituminous mixture to the paver except that hauling on partially completed segments will be permitted if the thickness of binder in-place is greater than 100 mm (4 inches), the last paving lift has cooled a minimum of 24 hours and the air temperature is below 30 °C (85 °F.). When hauling is allowed, the load limit restrictions given in the following table will be strictly enforced. In addition, a traffic pattern shall be established that will vary across the width of the pavement and "tracking" of vehicles one directly behind the other will not be allowed at any time.

LOAD LIMIT RESTRICTIONS				
Total Lift Thickness mm	Type of Hauling Below 30 °C (85 °F.)			
100-180 (4-7)	Unloaded	None		
180-240 (7-9.5)	Legally Loaded	Unloaded		
Greater than 240 (9.5)*	Legally Loaded	Legally Loaded		

<sup>\*</sup>With the last lift having cooled a minimum of 12 hours.

Permissive hauling on the partially completed pavement, however, does not relieve the Contractor of his/her responsibility for damage done to the pavement. Any portion of the full-depth pavement that is damaged by hauling on it shall be removed and replaced, or otherwise repaired to the satisfaction of the Engineer, by the Contractor at his/her own expense.

Cross-overs used to transfer haul trucks from one roadway to the other shall be not less than 300 m (1000 ft.) apart and shall be constructed of material that will prevent tracking dust or mud on the completed bituminous concrete layers. The cost of constructing, surfacing, maintaining and removing cross-overs shall be at the Contractor's expense.

**407.09 Surface Tests.** The finished surface of the pavement shall be tested using a California Profilograph or an approved equivalent or a 5 m (16 ft.) straightedge as specified below. The Contractor shall remove all objects and debris from the pavement surface prior to the required profilograph or straightedge measurements.

(a) 5-m (16-ft.) Straightedge. Pavement surfaces listed in Table 1 shall be tested in the wheel paths with a 5-m (16-ft.) straightedge set to the tolerance specified.

Table 1	
Location	Tolerance
Ramps, Loops and Climbing Lanes	6 mm (1/4")
Mainline Gaps ≤ 160 m (0.1 mile)	6 mm (1/4")
Bridge Approaches	6 mm (1/4")
Side Roads & Side Streets > 180 m (600 ft.) in length	6 mm (1/4")
15 m (50 ft.) from Bridge Approaches or Existing	
Pavement or Mainline Gaps	6 mm (1/4")
All curves ≤ 300 m (1000 ft.) radius including S.E. transitions	10 mm (3/8")
Acceleration Deceleration Lanes	10 mm (3/8")
Side Streets ≤ 180 m (600 ft.) in length	10 mm (3/8")
Turn Lanes, Storage Lanes and Crossovers, Etc.	10 mm (3/8")
Intersections	10 mm (3/8")

A 5 m (16 ft.) straightedge set to a 5 mm (3/16 inch) tolerance will be used to test the mainline pavement in lieu of the California Profilograph where the posted speed, as determined by the contract signing requirements, is:

- (1) Less than or equal to 70 km/h (40 mph) or
- (2) Greater than 70 km/h (40 mph) with a net project length of less than 1600 m (1 mile).

Surface variations which exceed the above tolerances shall be marked by the Engineer and removed by the Contractor with an approved grinding device consisting of multiple saws. The use of the bush hammer or other impact devices will not be permitted.

## (b) Profilograph.

(1) General. All mainline pavement shall be tested with a California Profilograph or approved equivalent. Mainline pavement is defined as all pavement except that listed in Table 1 located in (a) above and other miscellaneous pavement surfaces as determined by the Engineer. The profile will terminate 15 m (50 ft.) from each wide flange beam terminal joint, bridge approach pavement or existing pavement which is joined by the new pavement.

The Contractor shall furnish paving equipment and employ methods that produce a riding surface having a maximum profile index of 160 mm/km (10 inches/mile) for any 160 m (0.1 mile) segment except as

provided for elsewhere.

When starting up paving operations or after a long shutdown period, pavement surface will be tested the first several days with the profilograph as soon as the surface has cooled sufficiently to allow testing. For the purpose of surface tests, paving operations for Bituminous Concrete Pavement (Full-Depth) shall be interpreted as being concerned with the placement and compaction of the bituminous concrete surface course. Once the initial pavement smoothness, paving methods, and paving equipment are acceptable to the Engineer, daily profiles will be run during the next working day following placement of the pavement surface course.

The Contractor may use his/her profilograph on other jobs simultaneously provided such use will not interfere with the necessary testing as outlined above and scheduling can be agreed to by the respective Resident Engineers involved. If the contract does not require the Contractor to furnish a profilograph, the Department will furnish it.

(2) Profile Index and Price Adjustments. A daily Profile Index will be determined for each day's paving. Determination of the Profile Index will be according to Test Method No. California 526-D. A day's paving is defined as a minimum of 300 m (1000 ft.) of paving placed in a single day. If less than 300 m (1000 ft.) is paved, the day's production shall be grouped with the subsequent day's production. If a profile Index of 235 mm (15 inches) per km (mile) is exceeded in any day's production, the initial testing procedures will be resumed until the index is less than 235 mm (15 inches) per km (mile).

On the first paving day, a profile up to 235 mm (15 inches) per km (mile) for any 160 m (0.1 mile) segment will be accepted without applicable Price Adjustment and the profile will be excluded from the average profile index determined for the project.

Pavement Profiles will be taken 1 m (3 ft.) from and parallel to each edge for pavement placed at a 3.6 m (12 ft.) width, or less. When pavement is placed at a greater width than 3.6 m (12 ft.), the profile will be taken 1 m (3 ft.) from and parallel to each edge and each side of the planned longitudinal joint. When the pavement being constructed is contiguous with an existing parallel pavement which was not constructed as a part of this contract, the profile parallel with the edge of pavement contiguous with the existing pavement will not be taken. The profile index for each 160 m (0.1 mile) section will be the average of the profiles taken.

Acceptance and pay adjustments for Bituminous Concrete Pavement (Full Depth) will be based upon the smoothness of the final surface. Measurements on prior lifts are encouraged.

All areas represented by high points having deviations in excess of 8 mm (0.3 inches) in 8 m (25 ft.) shall be corrected by the Contractor with an approved grinding device consisting of multiple saws. The use

of a bushhammer or other impact devices will not be permitted.

When the average profile index for the entire project length does not exceed 8 mm/km (0.5 inch/mile), and no 160 m (0.1 mile) section has a profile index exceeding 160 mm/km (10 inches/mile), the contract unit price shall be increased according to the following Price Adjustment Schedule. When the profile index for the 160 m (0.1 mile) section does not exceed 160 mm/km (10 inches/mile) payment will be made at the contract unit price for that section. When the profile index for a 160 m (0.1 mile) section exceeds 160 mm/km (10 inches/mile) but does not exceed 235 mm/km (15 inches/mile) the contract unit price for that section will be reduced according to the following Price Adjustment Schedule.

### PRICE ADJUSTMENT SCHEDULE

Profile Index for Entire Project mm/km (inch/mile)	Percent of Unit Bid Price
3 (0.20) or less over 3 (0.20) to 6 (0.25) over 6 (0.25) to 8 (0.50)	103 102 101
Profile Index for 160 m (0.1 mile) Section, mm/km (inch/mile)	Percent of Unit Bid Price
over 8 (0.50) to 160 (10) over 160 (10) to 175 (11)	100 98
over 175 (11) to 190 (12)	96
over 190 (12) to 205 (13)	94
over 205 (13) to 220 (14)	92
over 220 (14) to 235 (15)	90
over 235 (15)	Corrective work required

(3) Correction: Except for bump corrections, the Contractor will not be allowed to make corrective grinding to increase his/her percent of pay when the final profile index is 235 mm/km (15 inches/mile) or less.

At the Contractor's option and expense, each 160 m (0.1 mile) section of pavement with a profile index greater than 235 mm/km (15 inches/mile) shall be either corrected until the measured profile index is less than or equal to 235 mm/km (15 inches/mile) or removed and replaced.

When the Contractor chooses the corrective grinding, 90 percent of the contract unit price will be the maximum amount of pay the Contractor shall receive for the section of pavement. When the Contractor chooses to remove and replace the section, the Contractor will be paid the percent of contract unit price which corresponds to the replaced section's final profile index.

On those 160 m (0.1 mile) pavement sections where corrections are necessary, second profilograph runs will be performed to verify that corrections have produced a Profile Index of 235 mm/km (15 inches/mile) or less. If the initial Profile Index is less than 235 mm/km (15 inches/mile), only the areas representing 8 mm (0.3 inch) deviations in 8 m (25 ft.) will be reprofiled for correction verification.

All ground areas shall be neat, rectangular areas of uniform surface appearance, bounded laterally by lane lines or edges of pavement. Determination of pavement thickness will be made after the removal of high spots.

**407.10 Tolerance in Thickness.** Determination of pavement thickness shall not be performed until after pavement surface tests and all corrective grinding have been completed as described above in Article 407.09. Adjustments made in the contract unit price for pavement deficient in thickness will be in addition to those made for Profile Index as specified in Article 407.09.

Determination of pavement thickness will be based on cores taken from a unit of the pavement having a surface area equal to or greater than 420 m<sup>2</sup> (500 sq. yds.). Determination of pavement thickness for areas less than 420 m<sup>2</sup> (500 sq. yds.) may be made from edge of pavement measurements or from before and after cross section measurements, as determined by the Engineer. Computation of thickness, and requirements relative to deficient thickness, shall be as specified herein:

- (a) Length of Units. The unit of surface area will be a continuous strip of pavement 300 m (1000 ft.) in length when possible. When the length of a continuous strip of pavement is less than 300 m (1000 ft.), the length of the unit to be used shall be identical to the length of the continuous strip.
- (b) Width of Units. The width of a unit will be the width from the pavement edge to the adjacent lane line, from one lane line to the next, or between pavement edges for single-lane pavements.
- (c) Cores. Cores will be taken from the pavement at such points as the Engineer shall select. When computing the thickness of a unit, not less than 3 cores will be taken.
- (d) Unit Deficient in Thickness. In considering any portion of the pavement that is deficient, the limits of the unit to be used in computing the deficiency will be determined by the Engineer, except that no portion of the pavement once included in such computation will be included in a second computation.
- (e) Determination of Thickness. The thickness of the pavement at the cored points will be the average caliper measurement of the cores taken at the respective points. The average thickness of the pavement will be determined by obtaining a weighted average of the thickness at the points where cores are taken from the particular unit, considering that each core represents the thickness of the pavement extending longitudinally in both directions half way to the nearest core, or to the end of the unit. Measurements which exceed the specified plan thickness will be considered as the specified thickness. Measurements which are less than the specified plan thickness by more than 5 percent, determined as specified in paragraphs (h) and (i) below, will not be included in obtaining

# Art. 407.10 Bituminous Concrete Pavement (Full-Depth)

a weighted average thickness.

- (f) Thickness Equals or Exceeds Specified Thickness. When the average thickness of a unit, determined as specified above, equals or exceeds the specified plan thickness, payment will be made at the contract unit price per square meter (square yard) for the specified thickness.
- (g) Thickness Deficient by 5 Percent or Less. When the average thickness of a unit determined as specified above, is less than the specified plan thickness by 5 percent or less, an adjusted unit price will be used in computing payment for the pavement involved. The adjusted unit price will be a percentage of the contract unit price as given in the following schedule:

Average Thickness Deficiency in Percent of Plan Thickness	Percent of Contract Unit Price
0.0 to 2.0	100
2.1 to 3.0	80
3.1 to 4.0	72
4.1 to 5.0	68

(h) Thickness Deficient by More than 5 Percent But Not More Than 10 Percent. When the thickness of the pavement at a cored point is less than the specified thickness by more than 5 percent but not more than 10 percent, additional cores will be taken on each side of such thin core at such intervals as the Engineer may select until cores are obtained which are not deficient in thickness by more than 5 percent. The average thickness of the pavement between the last points cored, and for the full width of the pavement unit, excepting any areas which are deficient in thickness by more than 10 percent, will be determined as a weighted average of the thickness at the cored point and an adjusted unit price will be used in computing payment for the pavement involved. The adjusted unit price will be a percentage of the contract unit price as given in the following schedule:

Average Thickness Deficiency in Percent of Plan Thickness	Percent of Contract Unit Price
5.1 to 7.5	57
7.6 to 10.0	50

(i) Thickness Deficient by More Than 10 Percent. When the thickness of pavement at a cored point is less than the specified thickness by more than 10 percent, additional cores will be taken on each side of such thin cores at such intervals as the Engineer may select until cores are obtained which are deficient in thickness by 10 percent or less. All pavement between the last points cored and for the full width of the unit of pavement will be considered thin by more than 10 percent, and such thin pavement shall be removed and replaced with pavement of the specified thickness unless the Engineer, at his/her option, permits in writing such thin pavement to remain in place.

If the thin pavement is removed and replaced with pavement of the

specified thickness, the replacement pavement will be paid for at the contract unit price per square meter (square yard), and no payment will be made for the thin pavement removed nor for the cost of removal. If the thin pavement is left in place, the Contractor will receive no compensation for the thin pavement and, in addition, an amount equal to 2 times the contract cost of the thin pavement will be deducted from the compensation due the Contractor.

**407.11 Widening.** The 5 m (16 ft.) straightedge shall be used in lieu of the profilograph on projects where the pay item Bituminous Binder Course in square meters (square yards) is specified.

#### 407.12 Method of Measurement.

- (a) Contract Quantities. The requirements for the use of contract quantities shall conform to Article 202.07(a).
- (b) Measured Quantities. Bituminous Concrete Pavement (Full-Depth) and Bituminous Binder Course will be measured in place and the quantity for payment shall be computed in square meters (square yards). The width of measurement shall be the top width of the bituminous concrete course as shown on the plans.
- **407.13 Basis of Payment.** Bituminous Concrete Pavement (Full-Depth) will be paid for at the contract unit price per square meter (square yard) for BITUMINOUS CONCRETE PAVEMENT (FULL-DEPTH) of the type and thickness specified.

When a light fog tack coat is required, it will be paid for according to Article 109.04.

When widening is being constructed and the entire pavement is being resurfaced, the binder for the widening will be paid for at the contract unit price per square meter (square yard) for BITUMINOUS CONCRETE BINDER COURSE, of the type and thickness specified. The surface and binder course resurfaced over the entire pavement will be measured and paid for according to Articles 406.23 and 406.24.

If the contract requires the Contractor to furnish a profilograph, furnishing a California type profilograph or approved equivalent, providing for its maintenance and jobsite transportation, furnishing the profile scale and bump template, profilograph paper and recorder pens, as outlined above, will be paid for at the lump sum price for FURNISH PROFILOGRAPH.

The cost of furnishing a 5-m (16-ft.) straightedge and providing for its jobsite transportation shall be considered as included in the various items involved and no additional compensation will be allowed.

## **SECTION 408. INCIDENTAL BITUMINOUS SURFACING**

**408.01 Description.** This work shall consist of the preparation of the base, the application of bituminous priming material, and the construction of a bituminous surface.

**408.02 Bituminous Mixtures.** The bituminous mixture for the incidental bituminous surface shall meet the requirements of the following Sections:

Note 1. Type 2, Mixture C or D shall be used.

#### CONSTRUCTION REQUIREMENTS

**408.03 General.** The base shall be prepared according to Section 358.

Areas where incidental bituminous surfacing will be subject to vehicular traffic shall have the base primed with Asphalt: RC-70, Asphalt: MC-30, or the same as used for prime on the mainline paving. The prime shall be applied according to Article 406.06 or 406.07 by methods approved by the Engineer. The bituminous prime material which will be subject to traffic shall be covered immediately following its application with fine aggregate spread at a uniform rate of 1 to 2 kg/m² (2 to 4 lbs. per sq. yd.) by hand methods. The fine aggregate for the prime coat shall conform to Article 1003.03. The exact rate of application of prime and fine aggregate will be specified by the Engineer.

The bituminous mixture may be spread and finished by approved hand methods or a finishing machine approved by the Engineer.

The bituminous mixture which will be subjected to vehicular traffic shall be rolled and compacted to the satisfaction of the Engineer with a tandem roller or vibratory roller meeting the approval of the Engineer. The bituminous mixture not subjected to traffic shall be compacted to the satisfaction of the Engineer.

**408.04 Method of Measurement.** Bituminous priming material will be measured for payment as specified in Section 1009.

Aggregate for covering the prime coat will be measured for payment in metric tons (tons) on platform scales meeting the approval of the Engineer.

Incidental bituminous surfacing will be measured for payment in metric tons (tons) on approved platform scales, and will include only those aprons which are constructed as a separate operation. Aprons placed with extendible screed wideners will be considered an integral part of mainline paving and will not be measured for payment as Incidental Bituminous Surfacing.

Preparation of base will not be measured for payment.

**408.05 Basis of Payment.** This work will be paid for at the contract unit price per metric ton (ton) or per liter (gallon) for BITUMINOUS MATERIALS (PRIME COAT), at the contract unit price per metric ton (ton) for AGGREGATE (PRIME COAT), and at the contract unit price per metric ton (ton) for INCIDENTAL BITUMINOUS SURFACING.

Preparing the base will not be paid for separately but shall be considered as included in the unit price bid for Incidental Bituminous Surfacing.

## P C CONCRETE PAVEMENTS AND SIDEWALKS



## SECTION 420. PORTLAND CEMENT CONCRETE PAVEMENT

**420.01 Description.** This work shall consist of a pavement composed of portland cement concrete with or without reinforcement, constructed on a prepared subgrade, or subbase, with or without forms.

**420.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 - Materials:

		Item	Article/Section
╒	(a)	Portland Cement Concrete	1020
	(b)	Concrete Reinforcement Bars, Fabric and Strands (Note 1) .	1006.10
	(c)	Pavement Longitudinal Metal Joints, Dowel Bars,	
		Expansion Joint Assembly, Contraction Joint Assembly	
		and Hinge Joint Assembly (Note 1)	1006.11
	(d)	Poured Joint Sealer	1050
	(e)	Preformed Expansion Joint Filler 10	51.08, 1051.09
	(f)	Protective Coat	1023.01
	(g)	Preformed Elastomeric Compression Joint Seals for Concrete	e 1053.01
	(h)	Non-Shrink Grout	1024.01
	(g)	Chemical Adhesive	1027.01

Note 1. All tie bars, dowel bars, reinforcement bars, and chair supports shall be epoxy coated. Chair supports for pavement fabric will not require epoxy coating.

**420.03 Equipment.** Equipment shall meet the requirements of the following Articles of Section 1100 - Equipment:

	Item Articl	e/Section
(a)	Forms for Pavement	1103.05
(b)	Formless Paver	1103.16
(c)	Form Grader	1103.06
(d)	Water Supply Equipment	1103.11
(e)	Batching and Weighing Equipment 1103.02	
(f)	Concrete Mixers	1103.01
(g)	Truck Agitator and Nonagitator Truck	1103.01
(h)	Heavy Subgrade Template	
(i)	Mechanical Form Tamper	1103.07
(j)	Mechanical Concrete Spreader	1103.12
(k)	Finishing Machine	1103.13
(I)	Mechanical Longitudinal Float	1103.15
(m)	Concrete Finisher Float	1103.14
(n)	Vibrators	1103.12
(o)	Miscellaneous Equipment	1103.17
(p)	Membrane Curing Equipment	1101.09
(q)	Subgrade Planer	1103.08
(r)	Subgrade Machine	
(s)	Pavement Surface Test Equipment	1101.10

#### CONSTRUCTION REQUIREMENTS

### 420.04 Reserved.

**420.05 Preparation of Subgrade or Subbase.** The subgrade or subbase shall be graded, compacted, trimmed, and finished according to Sections 301, except Articles 301.04 and 301.05 will not apply, and Sections 302, 310, 311, or 312 will apply as appropriate. The minimum width of the prepared subgrade or subbase shall be according to the cross sections as shown on the plans.

**420.06** Forms and Form Setting. Prior to the start of paving, forms shall be in place to accommodate at least one day's paving. Forms shall be clean and meet the requirements of Article 1103.05 prior to being set. Forms not meeting these requirements shall not be used. Forms shall be staked in place with at least 3 pins per 3-m (10-ft.) section of form. Form sections shall be locked together. The forms shall be supported for the full length and width of the form line by either the subgrade or subbase. If required by the Engineer, the subbase or subbgrade shall be tamped under the form line. The alignment of the form line shall be within a tolerance of  $\pm$ 5 mm (1/4 inch) with the plan edge of pavement. The elevation of the form shall be the plan elevation of the edge of pavement. Minor deviations in the subbgrade or subbase elevation may be corrected by placing compacted granular or subbase material in 10 mm (1/2 inch) lifts or less for low areas, provided the build up is not continuous. Shims or wedges shall not be used to build up the form line. High areas may be corrected by tamping or trimming as required. The minimum form height shall equal the plan pavement thickness. Form heights exceeding the pavement thickness may be used provided the forms are set and maintained at the plan elevation.

420.07 Placing. No concrete shall be mixed, placed or finished when the natural light is insufficient, unless an adequate and approved artificial lighting system is operated. Concrete shall not be placed on soft, muddy, or frozen subgrade or subbase. Concrete shall not be placed when the subgrade is frozen under permanent adjacent pavement. The concrete shall be unloaded into an approved mechanical concrete spreader and deposited uniformly across the subgrade or subbase as close as possible to its final position. The use of a mechanical spreader may be waived provided the concrete hauling equipment is equipped with a discharge system capable of distributing the concrete uniformly without segregation across the subgrade or subbase and meets the approval of the Engineer or a finishing machine meeting the requirements of the third paragraph of Article 1103.13 is utilized and When required, hand spreading shall be satisfactory results are obtained. accomplished with shovels. Paving shall be continuous between transverse joint locations shown on the plans. Transverse joint assemblies shall be protected from displacement or damage during the placement and consolidation of the concrete. Workers will not be allowed to walk in the freshly mixed concrete with boots or shoes coated with earth or foreign substances.

When approved in writing by the Engineer, pavements in excess of 7.2 m (24 ft.) or more in width may be constructed full width in a single operation.

Where concrete is to be placed adjoining a previously constructed lane of pavement, and mechanical equipment will be operated upon the existing lane of pavement, that lane shall have attained the strength specified for 14-day concrete.

If only finishing equipment is operated on the edge of the existing lane, paving in adjoining lanes may be permitted after 3 days.

Should any concrete materials fall on or be worked into the surface of a completed slab, they shall be removed immediately by approved methods.

### 420.08 Reserved.

420.09 Strike Off of Concrete and Placement of Reinforcement. Following placing, the concrete shall be struck off to conform to the cross section shown on the plans and to an elevation such that when the concrete is properly consolidated and finished, the surface of the pavement will be at the elevation shown on the plans. When reinforced concrete pavement is placed in 2 layers, the entire width of the bottom layer shall be struck off to such length and depth that the sheet of fabric or bar mat may be laid full length on the concrete in its final position without further manipulation. Bends or kinks in individual wires, or other irregularities, shall be corrected before the sheet is laid in the pavement. The reinforcement shall then be placed directly upon the concrete, after which the top layer of the concrete shall be placed, struck off and screeded. Any portion of the bottom layer of concrete which has been placed more than 20 minutes without being covered with the top layer shall be removed and replaced with freshly mixed concrete at the Contractor's expense. When reinforced concrete is placed in one layer, the reinforcement shall be positioned on chair supports spaced at maximum intervals of 1.2 m (4 ft.) in advance of concrete placement. The pavement reinforcement shall be placed such that the reinforcement in the completed pavement will be at the location shown on the plans with a placement tolerance for individual bars or individual wires of ±25 mm (±1 inch) horizontally and vertically.

Reinforcing steel shall be free from dirt, oil, paint, grease, or other materials which could impair bond with the concrete. All laps between sheets shall be held firmly together by wire or clips spaced not more than 1.2 m (4 ft.) apart.



- **420.10 Joints.** Joints shall be constructed of the type and dimensions, and at the locations required by the contract.
  - (a) Longitudinal Sawed Joint. Epoxy-coated deformed steel tie bars of specified length, size, spacing and material shall be placed perpendicular to the longitudinal sawed joints. They shall be placed by approved mechanical equipment, firmly supported on support pins, or rigidly supported on approved joint assemblies to prevent displacement.

Longitudinal sawed joints shall be constructed along the centerline of 2-lane pavements and along the lane lines of pavements [paved more than 2-lanes full width] in a single operation.

Longitudinal sawed joints shall be formed by cutting the surface of the pavement by means of approved concrete saws to the depth, width and line shown on the plans. Suitable guidelines or devices shall be used to assure cutting of the longitudinal joint on the true line as shown on the plans. Sawing of the longitudinal joint shall commence as soon as the concrete has hardened sufficiently to permit sawing without excessive ravelling, usually 4 to 24 hours. All joints shall be sawed to the full depth as shown on the plans before uncontrolled shrinkage cracking takes place. If necessary, the sawing operations shall be carried on both during the day and night regardless of weather conditions.

When multiple lane pavement is being placed in more than one operation, all required sawing of longitudinal joints shall be performed on the pavement in place before additional lanes are constructed. Sawing of a longitudinal joint shall be continuous across all transverse joints. Whenever sawing is discontinued, the cut shall terminate at a transverse joint. Water supply equipment for the sawing operations may be permitted on the pavement provided individual axle loads do not exceed 18 kN (4000 lbs.) and wheel loads are not applied within 1.8 m (6 ft.) of the pavement edges.

(b) Longitudinal Construction Joint. When adjacent lanes of pavement are constructed separately, epoxy-coated deformed steel tie bars of specified length, size, spacing and material shall be placed across the longitudinal construction joint to tie the lanes together. The epoxy-coated tie bars shall be installed in preformed or drilled holes along the vertical edge of the first lane placed as specified on the plans. The tie bars shall be installed with an approved non-shrink grout or chemical adhesive to provide a minimum pull requirement of 1) 35 kN for No. 15 bars (7750 lbs. for No. 5 and 5000 lbs. for No. 4 bars); 2) 49 kN (11,000 lbs.) for No. 20 (No. 6) bars; 3) 88 kN (19,750 lbs.) for No. 25 (No. 8) bars.. Holes shall be blown clean and dry prior to placing the grout or adhesive. The installation shall be with methods and tools conforming to the grout or adhesive manufacturer's recommendations. The Contractor shall load test 5 percent of the first 500 tie bars installed. No further installation will be allowed until the initial 5-percent testing has been completed and approval to continue installation has been given by the Engineer. Testing will be required for 0.5 percent of the bars installed after the initial 500. For each bar that fails to pass the minimum requirements, 2 more bars selected by the Engineer shall be tested. Each bar that fails to meet the minimum load requirement shall be reinstalled and retested. The equipment and method used for testing shall meet the requirements of ASTM E 488. All tests shall be performed within 72 hours of installation. The labor and materials required for the installation and testing of the tie bars will not be paid for separately, but shall be considered as included in the unit price bid for the portland cement concrete pavement item involved. The tie bars shall be installed and approved before concrete is placed in the adjacent lane.

In lieu of the above, the tie bar may be formed in place provided the bar length is increased to 750 mm (30 inches) and is maintained and in the proper location. Bending of the bar will not be allowed.

The sealant reservoir may be formed by sawing after the concrete has set as specified in (a) for longitudinal sawed joints, or it may be formed by hand tools when the concrete is in a plastic state.

(c) Transverse Expansion Joints. Load transfer devices shall be installed according to Article 420.10(e). The expansion joint filler shall be continuous from form to form, and shaped to the subgrade or subbase. Preformed joint filler shall be furnished in lengths equal to the pavement width or equal to the width of one lane. Damaged or repaired joint filler shall not be used unless approved by the Engineer.

The expansion joint filler shall be held in a vertical position. An approved

installing bar, or other device, shall be used if required to secure preformed expansion joint filler at the proper grade and alignment during placing and finishing of the concrete. Finished joints shall not deviate more than 5 mm (1/4 inch) in the horizontal alignment from a straight line. If joint fillers are assembled in sections, there shall be no offsets between adjacent units. No plugs of concrete shall be permitted anywhere within the expansion space.

(d) Transverse Contraction Joints. Transverse contraction joints shall consist of planes of weakness created by cutting grooves in the surface of the pavement and shall include load transfer devices. Sawed contraction joints shall be created by sawing grooves in the surface of the pavement, of the dimensions and at the spacing and lines shown on the plans, with an approved concrete saw. After each joint is sawed, the saw cut and adjacent concrete surface shall be thoroughly cleaned.

Sawing of the joint shall commence as soon as the concrete has hardened sufficiently to permit sawing without excessive ravelling, usually 4 to 24 hours. All joints shall be sawed to the full depth before uncontrolled shrinkage cracking takes place. If necessary, the sawing operations shall be carried on both during the day and night, regardless of weather conditions.

Curing covering shall be removed from the pavement only at the location where a joint is to be cut. Only sufficient covering shall be removed to provide the necessary room for working at the location of the joint. As soon as the joint has been cut, the covering shall be replaced. In no case shall the top surface and edges of the pavement be left unprotected for a period of more than 1/2 hour.

Water may be sprayed on the saw blade during the cutting. If necessary, a suitable stationary guide shall be used to prevent side swaying of the machine to ensure that the cut will be straight. Water shall be used, if necessary, to thoroughly clean the joint. All extraneous material, including free water, shall be removed from the joint opening by means of an air jet.

Widening of the sawed joint for transverse contraction joints that are to receive a preformed elastomeric compression joint seal shall be performed as a separate operation at a later date according to the provisions of Article 420.14(b).

(1) When contraction joints are to be sealed with a preformed elastomeric compression joint seal according to Article 420.14(b) and an uncontrolled crack develops ahead of the Contractor's joint sawing operations or within 2 m (6 ft.) of the joint because of non-functioning dowel assemblies, pavement removal and replacement will be required.

When uncontrolled cracks develop to one side of the sawed joint either immediately ahead of sawing operations or because of non-functioning dowel assemblies, the pavement within the lane where the cracks occur shall be removed and replaced. The minimum length of pavement removed shall be 2 m (6 ft.). If after removal operations,

it is determined that the load transfer assembly is malfunctioning or has been damaged, the entire assembly and an additional 1 m (3 ft.) on the uncracked side shall be removed and replaced. If cracking occurs on both sides of the same joint, the dowell assembly and a minimum of 1 m (3 ft.) on either side of the joint shall be removed and replaced. The Department will provide details and specifications of the repair procedure to the Contractor. The Contractor shall replace the pavement fabric for the length of the concrete replacement when the pavement is reinforced. The removal and replacement shall be at the Contractor's expense.

(2) When contraction joints are to be sealed with poured joint sealant according to Article 420.14(a), the sawing of any joint shall be omitted if a crack occurs at or near the joint location prior to the time of sawing. Sawing shall be discontinued when a crack develops ahead of the saw. Uncontrolled cracks, which the Engineer determines to be an acceptable joint, shall be routed and sealed according to Section 452, at the Contractor's expense. All contraction joints in lanes adjacent to previously constructed lanes shall be sawed before uncontrolled cracking occurs. If any portion of an uncontrolled crack at a transverse contraction joint extends outside the limits of the load transfer device, the pavement shall be removed and replaced as described above in (d)(1).

If extreme conditions exist which make it impractical to prevent erratic cracking by early sawing, the contraction joint groove shall be formed in a manner approved by the Engineer prior to initial set of the concrete.

(e) Load Transfer Devices. Dowels, when used, shall be held in position parallel to the surface and centerline of the slab by metal devices that meet the approval of the Engineer.

A light coating of oil shall be uniformly applied to the bars prior to placing the concrete. The welds in the assembly shall be securely made. A broken weld will be sufficient cause for the rejection of the length or section of the assembly in which it occurs.

The dowel bar assembly shall be completely assembled before being placed in position. The assembly shall be installed so that the dowel bars are parallel to the proposed pavement surface and to each other and so that the assembly is at right angles to the centerline of the pavement. All shipping tie wires shall be cut after the assembly is secured in place. At the location of each dowel bar assembly, the subgrade or subbase shall be reshaped and re-tamped when necessary.

When the dowel bar assembly is in place on the subgrade or subbase, the assembly shall act as a rigid unit with each component part securely held in position relative to the other members of the assembly. The entire assembly shall be held securely in place during placing, consolidating, and finishing of the concrete, by means of nails which shall penetrate the stabilized subbase. At least 10 nails shall be used for each 3, 3.3, or 3.6-m (10, 11, or 12-ft.) section of assembly. Bearing plates shall be punched to

receive the nails. Metal stakes shall be used instead of nails, with soil or granular subbase, and shall penetrate the subbase at least 300 mm (12 inches).

The Contractor shall check the horizontal alignment of the dowel bars by an approved means and the vertical alignment of each dowel bar by means of a leveling device so constructed that it may be adjusted to the correct grade. Any deviation from correct alignment greater than 3 mm (1/8 inch) in 300 mm (12 inches) shall be corrected before any concrete is placed.

Care shall be exercised in depositing the concrete at the dowel bar assemblies so that the horizontal and vertical alignment will be retained.

The sawing of all joints shall be included in the cost of the particular pavement item in which it is installed.



Transverse Hinge Joint. Transverse hinge joints shall consist of planes of weakness created by cutting grooves in the surface of the pavement and shall include hinge joint assemblies placed along the line of and symmetrical to transverse joints and rigidly secured by approved chair assemblies to prevent displacement during concrete placement. Transverse hinge joints shall be formed by sawing grooves in the surface of the pavement at the locations and to the dimensions shown on the plans with an approved concrete saw. Sawing shall be performed according to the requirements specified in (d) for transverse contraction joints.

The sawing of any joint shall be omitted if an uncontrolled crack occurs within 75 mm (3 inches) of either side of the joint prior to the time of sawing. Sawing shall be discontinued when a crack develops ahead of the saw. Uncontrolled cracks within these limits will be considered an acceptable hinge joint provided the uncontrolled crack is routed, cleaned, and sealed according to Section 452, at the Contractors expense.

If an uncontrolled crack develops on one side of the hinge joint, more than 75 mm (3 inches) from the joint, a minimum of 2 m (6 ft.) of pavement on that side of the joint within the lane containing the cracking shall be removed and replaced. If cracking occurs on both sides of the joint, more than 75 mm (3 inches) from the joint, the tie-bar assembly and a minimum of 1 m (3 ft.) of pavement each side of the joint shall be removed and replaced. Removal and replacement of the pavement shall be done at the Contractor's expense. The Department will provide drawings and specifications of the repair procedure to the Contractor.

(g) Transverse Construction Joints. Transverse construction joints shall be constructed when there is an interruption of more than 30 minutes in the concreting operations. The transverse construction joint shall be formed by means of a suitable header, accurately set and securely held in place in a plane perpendicular to the surface of the pavement.

When the pavement is constructed with pavement fabric reinforcement, no transverse construction joint shall be constructed within 3.0 m (10 ft.) of a contraction joint. The construction joint shall conform to the details shown on the plans, except that if sufficient concrete has not been mixed at the

time of interruption to form a slab extending at least 3.0 m (10 ft.) beyond the last contraction joint, the excess concrete back to the last preceding joint shall be removed and disposed of as directed by the Engineer and the construction joint shall be constructed as a contraction joint.



For hinge-jointed pavement, all transverse construction joints shall be formed at a transverse hinge joint or transverse contraction joint and shall be constructed to the same configuration as the joint designated for that location. The termination of a construction project shall be constructed as a hinge joint.

**420.11 Final Strike Off, Consolidation, and Finishing.** The sequence of operations shall be the strike off and consolidation, screeding, longitudinal floating, straightedging, edging and final finish.

The consolidation and finishing operations shall at all times be such as to produce a satisfactory surface. If this provision is not being complied with, the paving operations will be stopped by the Engineer and the Contractor will not be permitted to proceed until satisfactory results are assured.

All portland cement concrete pavement shall be vibrated with a surface pan type vibrator or internal vibrator approved by the Engineer. Vibrators shall not come in contact with a joint assembly, the grade or side forms. Vibration of the concrete shall not exceed 10 seconds at any one location.

- (a) Finishing. The following methods of finishing concrete shall be used:
  - (1) Vibratory Method. After the concrete has been struck off, the concrete shall be vibrated for the full width of the concrete pavement. If uniform and satisfactory density of the concrete is not obtained by the vibratory method at joints, along forms, at structures, and throughout the pavement, the Contractor will be required to furnish equipment and methods which will produce pavement conforming to the Specifications. The Contractor shall have a satisfactory tachometer available for checking the operating frequency of the vibrating elements.

The concrete shall be distributed or spread with an approved mechanical spreader as soon as placed. As soon as the concrete has been spread and consolidated, it shall be screeded by an approved finishing machine. The tops of the forms shall be kept clean by an effective device attached to the machine and the travel of the machine on the forms shall be maintained true without lift, wobbling or other variations tending to affect a uniform finish. If the rate of depositing concrete is in excess of the amount which the finishing machine can strike off and consolidate, a second finishing machine shall be provided and used.

(2) Hand Finishing. Hand finishing methods will not be permitted except in the event of breakdown of the mechanical equipment. Hand methods may be used to finish the concrete already deposited on the grade when the breakdown occurs. (3) Vibrating Screed. An approved vibrating screed may be used to strike off and consolidate variable width pavement, pavement less than 3 m (10 ft.) in uniform width and paving gaps at driveways, intersections, etc. The vibration shall be shut off whenever forward motion of the screed is stopped. The vibrating screed for the surface shall be at least 600 mm (2 ft.) longer than the maximum width of the slab to be struck off. It shall be of approved design, sufficiently rigid to retain its shape and be constructed either of metal or of other suitable material shod with metal.

In operation, the vibrating screed shall be moved forward on the forms, moving always in the direction in which the work is progressing and so manipulated that neither end is raised from the side forms during the striking off process. If necessary, this shall be repeated until the surface is of uniform texture, true to grade and cross section, and free from porous areas.

- (b) Longitudinal Floating. After the concrete has been struck off and consolidated, it shall be further smoothed and trued, by means of an approved float, using one of the following methods:
  - (1) Mechanical Longitudinal Float Method. The mechanical longitudinal float shall be of a design approved by the Engineer, and shall be in good working condition. The tracks from which the float operates shall be in good working condition. The tracks from which the float operates shall be accurately adjusted and coordinated with the adjustments of the transverse finishing machine so that a small amount of mortar is carried ahead of the float at all times. The forward speed shall be adjusted so that the float will lap the distance specified by the Engineer on each transverse trip. The float shall pass over each area of pavement at least 2 times, but excessive operation over a given area will not be permitted. Excess water or soupy material shall be wasted over the side forms on each pass.
  - (2) Concrete Finisher Float Method. The Contractor may use a machine, after approval by the Engineer, composed of a smoothing float or floats, suspended from and guided by a rigid frame. The frame shall be carried by 4 or more wheels riding on, and constantly in contact with, the side forms.
  - (3) Hand Method. This method may only be used in an emergency or if specified. The hand-operated longitudinal float shall be not less than 3 m (10 ft.) in length and properly stiffened to prevent flexibility and warping during the finishing operation. The handle shall be not less than 1 m (3 ft.) longer than 1/2 the width of the slab. The float shall be used parallel to the road centerline and passed gradually from one side of the pavement to the other to fill depressions or cut down high areas. Movement ahead along the centerline of the pavement shall be in successive advances of not more than 1.5 m (5 ft.). Any excess mortar shall be wasted over the side forms on each pass. Floating shall continue until the entire surface is found to be free from variations and the slab conforms to the required grade and cross section.

If necessary, following one of the preceding methods of floating, long

handled floats having blades not less than 900 mm (3 ft.) in length and 150 mm (6 inches) in width may be used to smooth and fill in open-textured areas in the pavement, but shall not be used to float the entire surface of the pavement in lieu of, or supplementing one of the preceding methods of floating.

Straightedge Testing and Surface Correction. After the floating has been completed, but while the concrete is still plastic, the surface of the concrete shall be tested for trueness with a 3 m (10 ft.) straightedge. For this purpose, the Contractor shall furnish and use an accurate 3 m (10 ft.) straightedge which has a handle not less than 1 m (3 ft.) longer than 1/2 the width of the slab. The straightedge shall be held in contact with the surface in successive positions parallel to the road centerline and the whole area gone over from one side of the slab to the other. Advance along the road shall be in successive stages of not more than 1/2 the length of the straightedge. Any depressions found shall be immediately filled with freshly mixed concrete, struck off, consolidated and refinished. High areas shall be cut down and refinished. Special attention shall be given to assure that the surface across joints meets the requirements for smoothness. Straightedge testing of the surface shall continue until the entire surface is found to be free from variations from the straightedge, and the slab conforms to the required grade and cross section.

If the hand method using a 3-m (10-ft.) longitudinal float is permitted and surface corrections made as specified in Article 420.11(b), straightedge testing will not be required.

- (d) Edging. After longitudinal floating, straightedging, and before the final finish, the edges of the pavement shall be carefully finished with an edging tool having a radius of not more than 6 mm (1/4 inch) and the pavement edge left smooth and true to line.
- (e) Final Finish. Type A final finish shall be used unless Type B is specified.
  - (1) Type A. Type A final finish shall be obtained by the use of a carpet drag composed of an artificial turf approved by the Engineer followed immediately by a mechanically operated metal comb transverse grooving device.

The artificial turf shall be made of molded polyethylene with synthetic turf blades approximately 20 mm (0.85 inch) long and contain approximately 7,200 individual blades per 0.1 m² (sq. ft.). The artificial turf shall be suitably attached to an approved device that will permit control of the time and rate of texturing. The artificial turf carpet shall be full pavement width and of sufficient size that during the finishing operation, approximately 600 mm (2 ft.) of carpet parallel to the pavement centerline will be in contact with the pavement surface. The drag shall be operated in a longitudinal direction so as to produce a uniform appearing finish meeting the approval of the Engineer. If necessary for maintaining intimate contact with the pavement surface, the carpet may be weighted.

The metal comb shall consist of a single line of tempered spring steel tines spaced at 20 mm (3/4 inch) centers and securely mounted in a

suitable head. The tines shall be flat and of a size and stiffness sufficient to produce a groove of the specified dimensions in the plastic concrete without tearing of the pavement edge or surface. Contractor shall modify the equipment or operations if an acceptable pavement edge or surface is not produced. The mechanically operated metal comb shall be attached to an exclusive piece of equipment which is mechanically self-propelled and capable of traversing the entire payement width being placed in a single pass. The artificial turf carpet drag may be attached to this piece of equipment provided a surface texture is produced satisfactory to the Engineer. The tining device shall be operated so as to produce a relatively uniform pattern of grooves perpendicular to the pavement centerline spaced at approximately 20 mm (3/4 inch) centers, 3 to 5 mm (1/8 to 3/16 inch) deep and 2.5 to 3.2 mm (0.100 to No other operation will be permitted with this 0.125 inch) wide. equipment. Separate passes will be required for the turf dragging operation and the tining operation.

Hand tining or tining with a mechanically operated comb combined with the curing equipment specified in Article 1101.09 will be permitted where the Specifications permit hand finishing or vibratory screeds, one lane construction up to 5 m (16 ft.) wide, gaps, projects with a net length of 800 m (1/2 mile) or less, and where the production rate on any paving day will be less than 1200 m³ (1,500 cu. yds.) per day. A foot bridge shall be provided for the hand tining operation for all pavement over 3.6 m (12 ft.) wide, unless it can be demonstrated to the satisfaction of the Engineer that an alternate texturing operation produces satisfactory results.

Pavement texture not meeting the above spacing and depth requirements shall be corrected by the Contractor at his/her own expense. Regrooving in either plastic or hardened concrete shall be done transversely meeting the spacing and depth requirements as stated above.

- (2) Type B. Type B final finish shall be obtained by the use of a single artificial turf drag. The artificial turf shall conform and be operated according to the requirements for Type A finish, except this device shall not be attached to other pieces of equipment in the paving train but shall be a separate piece of equipment used expressly for the texturing operation. Pavement texture damaged by rain may be restored by retexturing the concrete while in the plastic state.
- **420.12 Surface Tests.** The surface of the finished pavement shall be tested and be within the tolerances specified in Article 407.09 and as follows:

Testing with a profilograph for the first several days of paving following initial start up or after a long shutdown period shall be performed as soon as the concrete has cured sufficiently to permit the testing.

When the average profile index for the entire project length does not exceed 67 mm/km (4.25 inch/mile), and no 160 m (0.1 mile) section has a profile index exceeding 160 mm/km (10 inches/mile), the contract unit price shall be increased

according to the following Price Adjustment Schedule. When the profile index for a 160 m (0.1 mile) section does not exceed 160 mm/km (10 inches/mile) payment will be made at the contract unit price for that section. When the profile index for a 160 m (0.1 mile) section exceeds 160 mm/km (10 inches/mile) but does not exceed 235 mm/km (15 inches/mile) the contract unit price for that section will be reduced according to the following Price Adjustment Schedule.

## PRICE ADJUSTMENT SCHEDULE

Profile Index for Entire Project mm/km (inch/mile)	Percent of Unit Bid Price
36 (2.25) or less over 36 (2.25) to 53 (3.25) over 53 (3.25) to 67 (4.25)	103 102 101
Profile Index for 160 m (0.1 mile) Section, mm/km (inch/mile)	Percent of Unit Bid Price
over 67 (4.25) to 160 (10) over 160 (10) to 175 (11) over 175 (11) to 190 (12) over 190 (12) to 205 (13) over 205 (13) to 220 (14) over 220 (14) to 235 (15)	100 98 96 94 92 90
over 235 (15)	Corrective work required

Membrane curing damaged during the testing operations shall be repaired by the Contractor, at his/her own expense, as directed by the Engineer.

On all areas where corrective grinding is done, the Contractor shall apply, at his/her own expense, a protective coat according to Article 420.21.

Curing and protective covers if used, shall be removed from the pavement for the required profilograph and straightedge measurements and properly replaced when the testing is completed according to Article 1020.13(b).

**420.13 Removing Forms.** Forms shall not be removed from freshly placed concrete until it has set for at least 12 hours, except auxiliary forms used temporarily in widened areas. Forms shall be removed carefully avoiding damage to the pavement. After the forms have been removed, the sides of the slab shall be cured as outlined in one of the methods indicated in Article 1020.13.

Any honeycombed or porous areas shall be corrected as directed by the Engineer. Effective surface drainage shall be provided and maintained to prevent the accumulation of water along the edges of the pavement. Underwash along the edges shall be prevented, where grades are such as to cause this action, by placing earth against the edges to the full height of the slab.

- **420.14 Sealing Joints.** Joints shall be sealed, as shown on the plans, before the pavement is opened to traffic, including construction traffic, and as soon after the curing period as feasible.
  - (a) Poured Joint Seal. Just prior to sealing, each joint shall be thoroughly

cleaned of all foreign material, including membrane curing compound, and the joint faces shall be clean and surface dry when the seal is applied. Material for seal applied hot shall be stirred during heating so that localized overheating does not occur.

The sealing material shall be applied to each joint opening to conform to the details shown on the plans or as directed by the Engineer. The pouring shall be done in such a manner that the material will not be spilled on the exposed surfaces of the concrete.

Any excess material on the surface of the concrete pavement shall be removed immediately and the pavement surface cleaned. The use of sand or similar material as a cover for the seal will not be permitted. Poured joint sealing material shall not be placed when the air temperature in the shade is less than 10 °C (50 °F.), unless approved by the Engineer.

When sand is to be placed for the joint filler prior to sealing expansion joints with a hot-poured joint sealer, the sand shall be a dry, durable sand with 100 percent passing the 4.75 mm (No. 4) sieve and no more than 3 percent passing the 75  $\mu$ m (No. 200) sieve when tested according to AASHTO T 11.



Preformed Elastomeric Compression Joint Seal. The joint shall be sawed to the dimensions shown on the plans in 2 stages. The first stage shall consist of sawing the joint to prevent random cracking as specified in Article 420.10(c). The second stage saw cut shall be performed no sooner than 72 hours after the concrete has been placed and not until after all longitudinal joints have been sealed with a poured joint seal as specified in Article 420.14(a). The edges shall be beveled by either a cutting or grinding device attached to the second stage sawing blade following the sawing operation. When unsatisfactory results are being obtained, the Contractor shall, at the direction of the Engineer, modify or change the method of producing bevels. The second stage sawing operation may be delayed except that if the joint to be sawed has opened more than 3 mm (1/8 inch), as determined by measuring cracking on the slab side, the Contractor shall saw an additional 1.5 mm (1/16 inch) in width for each 1.5 mm (1/16 inch) of opening exceeding the 3 mm (1/8 inch).

The joints shall be thoroughly cleaned, using whatever equipment or method is necessary, prior to sealing. When the joint is free of foreign material and dry, the preformed elastomeric joint sealer shall be installed by approved machine methods so that no twisting, rolling or misalignment with the opposite top edge occurs. The joint shall be sealed across the full width of the entire pavement with one piece of sealer material. The seal shall be secured in place with a lubricant adhesive which shall cover both sides of the seal. The lubricant adhesive may be applied to either the concrete or seal or both. Any adhesive on the top of the seal shall be removed. The sealer shall be installed in a compressed condition below the bottom of the beveled edge and not more than 8 mm (5/16 inch) below the surface of the pavement.

The method of installation shall be such that the joint sealer material will not be stretched more than 5 percent nor compressed more than 2 percent

of the minimum theoretical dimension. The method of installation shall be checked for stretching and compression by installing sealer in 5 transverse joints and removing the sealer immediately after installation and checking the length. An alternate method for checking stretch and compression, where applicable, may be performed by premarking or pre cutting the sealer to length prior to installation. If the measurement of any of these 5 sealers demonstrates that stretching in excess of 5 percent or compression in excess of 2 percent is occurring, the installation method shall be modified to meet the requirements. Once sealing operations have started, one joint per every hundred shall be removed and checked for stretch in excess of 5 percent or compression in excess of 2 percent. If an unsatisfactory condition is found, the joint seals on either side shall be removed until the condition disappears and the affected joints shall be replaced in a satisfactory manner at the expense of the Contractor.

The joints shall be sealed on all pavements before discontinuing paving operations when the work is suspended during the winter.

**420.15 Protection of Pavement.** The Contractor shall protect the pavement and its appurtenances against both public traffic and traffic caused by the Contractor's own employees and agents. This shall include flaggers to direct traffic and the erection and maintenance of standard warning signs, lights, pavement bridges or crossovers. Earth berms shall be constructed along each edge to the full height of the pavement, and of such width as to reduce traffic hazard, yet will not impound water on the pavement surface.

Any damage to the pavement occurring prior to final acceptance shall be repaired or the pavement replaced in a manner acceptable to the Engineer by the Contractor at his/her own expense.

- **420.16** Opening to Traffic. The road shall be opened to traffic according to Article 701.05(c)(6).
- **420.17 Slip Form Method.** At the option of the Contractor, slip form paving methods may be used for construction of the pavement.

The slip form paving machine shall be approved by the Engineer prior to starting the paving operations. It shall be self-propelled and be designed for the specific purpose of placing, consolidating and finishing concrete pavement slabs true to grade and cross section in one complete pass without the use of fixed side forms. The machine shall be equipped with means for spreading the concrete to a uniform depth before it enters the throat of the machine. The machine shall vibrate the concrete either externally or internally with sufficient intensity to consolidate the concrete throughout its entire depth and width.

All paving equipment, including the spreader, paver, float, texturing machine and curing machine shall ride on the stabilized subbase. The subbase shall be constructed to a width 150 mm (6 inches) wider than the width from outside-to-outside of the slip form paver's tracks.

The slip form paving equipment shall spread, consolidate, screed and float finish the freshly placed concrete in one pass in a manner such that a minimum of hand floating will be required. The operations of depositing, spreading, consolidating, and finishing shall be a continuous operation of the paver as much as possible. Frequent

starting and stopping of the paver shall be kept to a minimum.

Final finish shall be obtained as specified in Article 420.11(e).

Curing of the surface and edges shall be done according to one of the methods specified in Article 1020.13.

In order that the concrete may be properly protected against the effects of rain before the concrete is sufficiently hardened, the Contractor will be required to have available at all times materials for the protection of the edges and surface of the unhardened concrete. Such protective materials shall consist of standard metal forms or wood plank having a nominal thickness of not less than 25 mm (1 inch) and a nominal width of not less than the thickness of the pavement at its edge for the protection of the pavement edges, and covering material such as burlap or curing paper for the protection of the surface of the pavement. When rain appears imminent, all paving operations shall stop and all available personnel shall begin placing forms against the sides of the pavement and covering the surface of the unhardened concrete with the protective covering.

The surface of the completed pavement shall be within the tolerance specified in Article 420.12, except that a tolerance will be permitted for edge slump, exclusive of edge rounding.

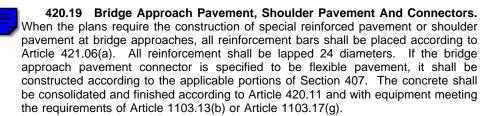
Uplift of the outer edge of slip-formed pavement will not be allowed and shall be corrected if it occurs before the concrete has hardened to allow for cross slope drainage. If operational adjustments cannot correct the uplift, the paving operations will be suspended until the equipment is properly repaired.

Edge slump will be measured by placing a 1.2-m (4-ft.) straightedge perpendicular to the centerline of pavement and taking the vertical measurement at the edge of the completed pavement where the normal edge rounding begins. The following edge slump tolerances will be allowed:

- (a) Edge slump of the concrete pavement, exclusive of edge rounding, may vary up to 13 mm (1/2 inch) at locations where no additional concrete work is to be constructed immediately adjacent to the pavement being placed. Edge slump will be tested as soon as practical after paving operations begin. Any edge settlement in excess of 13 mm (1/2 inch) shall be corrected before the concrete has hardened. When edge settlements in excess of 13 mm (1/2 inch) persist, paving will be suspended and operational corrections shall be made before the Engineer will permit the resumption of paving. If the Contractor consistently fails to construct pavement within these specified tolerances, the use of slip form methods will be discontinued and the pavement shall be placed by means of conventional forms.
- (b) Edge slump of the concrete pavement in excess of 6 mm (1/4 inch) will not be allowed at locations where additional concrete work (widening, ramps, additional lanes, curb and gutter, etc.) is to be constructed immediately adjacent to the pavement being placed. The Contractor shall correct any edge settlement in these areas before the concrete has hardened. If the concrete has hardened, edge slump shall be corrected by removing no less than 3 m (10 ft.) in length of defective pavement full depth and replacing the pavement as part of the adjacent widening, ramps, additional lanes, curb and gutter, etc. All pavement removed for edge slump shall be sawed

full depth longitudinally for a width not to exceed 300 mm (1 ft.). The transverse saw cuts and reinforcement replacement shall be as provided in Article 442.06. The pavement shall be carefully removed and No. 25 (No. 8) epoxy-coated deformed reinforcement bars 600 mm (24 inches) long shall be grouted in place in holes drilled at mid-depth on 750-mm (30-inch) centers along the pavement edge. Variations in the edge of pavement that cannot be corrected by removing 300 mm (1 ft.) off the side of the lane shall be removed a full lane width. All full lane width removal and replacement shall be done according to Section 442 and shall be at least 3 m (10 ft.) in length. This work shall be done at the Contractor's expense and no additional compensation will be allowed. If edge slump is a continuous problem in areas continuous to adjacent concrete work, the concrete shall be placed and finished either as required for standard paving methods or by use of false forms placed adjacent to the slip formed pavement edge. The false forms shall be of sufficient thickness to maintain the proper shape and continuity of the form line and will be approved by the Engineer. Bracing of the forms shall be such that at no time will there be more than 3 m (10 ft.) of unbraced false forms. False forms shall remain in place for at least 90 minutes, or for a longer period of time as directed by the Engineer when their removal is apt to cause injury to the adjacent concrete.

**420.18 Tolerance in Thickness.** Determination of pavement thickness and computation of thickness and requirements relative to deficient thickness shall be as specified in Article 407.10, except that the width of a pavement unit shall be the width from the pavement edge to the adjacent longitudinal joint, from one longitudinal joint to the next, or between pavement edges where there is no longitudinal joint.



**420.20 Adjacent to Railroad Grade Crossing.** Portland cement concrete pavement adjacent to railroad grade crossings shall be constructed according to the details shown on the plans except that when the mainline pcc pavement thickness is greater than 250 mm (10 inches), the thickness of the slab adjacent to the railroad crossing shall be increased to the same thickness as the mainline.

The No. 25 (No. 7) reinforcement bars in the slab adjacent to the railroad crossing shall be lapped a minimum of 650 mm (26 inches). A longitudinal construction joint will be permitted in lieu of the sawed longitudinal joint when stage construction is used.

The bituminous plug shall be constructed of bituminous concrete binder course mixture according to the applicable requirements of Section 406. At the Contractor's option, Class I bituminous concrete surface course mixture may be used in lieu of the binder course mixture.

**420.21 Protective Coat Application.** When pavement is constructed after October 15 and it will be opened to traffic prior to the following April 15, or when directed by the Engineer, a protective surface treatment consisting of 2 coats of boiled linseed oil mixture shall be applied to the surface of the pavement and appurtenances, when the concrete is at least 14 days old and before the pavement is marked and opened to traffic.

Before the surface treatment mixture is applied, the concrete surface shall have at least a 48-hour drying period since the last rain and shall be cleaned to remove all oil, grime and loose particles which would prevent the mixture from penetrating the concrete.

The surface treatment mixture shall consist of 50 percent boiled linseed oil and 50 percent petroleum spirits by volume.

The rate of application for each coat shall be not more than 11  $m^2$  /L (50 sq. yds. per gal.) of mixture.

The surface treatment mixture shall be sprayed on the surface with a mechanical spraying machine which will perform the work in a satisfactory manner. The spray nozzles shall be within 450 mm (18 inches) of the concrete or as directed by the Engineer. The interior of the distributor tank shall be thoroughly cleaned prior to placing the surface treatment mixture therein. Unless otherwise directed by the Engineer, the temperature of the concrete and air shall be 10 °C (50 °F.) or higher at the time of application.

The second application of the surface treatment mixture shall not be made until the concrete, in the opinion of the Engineer, has regained its dry appearance.

CAUTION: As linseed oil - petroleum spirits mixture has a low flash point and is readily flammable, fire of all sorts, including cigarettes and sparks, shall be carefully guarded against. Traffic shall be prohibited from the area until the concrete has regained its dry appearance.

If an application of sand is required by the Engineer for blotter material, it will be paid for according to in Article 109.04.

### 420.22 Method of Measurement.

- (a) Contract Quantities. The requirements for the use of contract quantities shall conform to Article 202.07(a).
- (b) Measured Quantities. Portland cement concrete pavement, bridge approach pavement, bridge approach shoulder pavement and bridge approach pavement connectors will be measured for payment in place and the area computed in square meters (square yards). The length will be measured along the centerline of the surface of each roadway, ramp, or approach pavement. The width will be the width of pavement as shown on the plans. In computing the area for payment for bridge approach pavement and bridge approach shoulder pavement, a deduction will be made for the area displaced by the inlet.

Reinforcement bars used in portland cement concrete pavement adjacent to railroad grade crossings will be measured for payment in kilograms (pounds) as specified in Article 508.07.

The quantity of pavement fabric will be the computed surface area of the concrete pavement in which the pavement fabric is installed and no allowance will be made for laps, splices or portions of sheets not used. When the plan width of subbase is extended for the slip form method, such extended width will not be measured for payment but shall be considered as included in the unit price bid for the item of subbase involved.

The areas upon which the protective coat is applied, except where corrective grinding has been performed, will be measured for payment and computed in square meters (square yards).



420.23 Basis of Payment. This work will be paid for at the contract unit price per square meter (square yard) for PORTLAND CEMENT CONCRETE PAVEMENT, HIGH- EARLY-STRENGTH PORTLAND CEMENT CONCRETE PAVEMENT, and PORTLAND CEMENT CONCRETE PAVEMENT (HINGE-JOINTED), of the thickness specified; at the contract unit price per square meter (square yard) for BRIDGE APPROACH PAVEMENT; at the contract unit price per square meter (square yard) for PC CONCRETE BRIDGE APPROACH SHOULDER PAVEMENT, BRIDGE APPROACH PAVEMENT CONNECTOR (PCC), or BRIDGE APPROACH PAVEMENT CONNECTOR (FLEXIBLE); and at the contract unit price per square meter (square yard) for PAVEMENT FABRIC.

The unit price bid for Bridge Approach Pavement and PC Concrete Bridge Approach Shoulder Pavement shall include tie bars, preformed joint seal, polyethylene bond breaker, granular subbase, reinforcement bars, the concrete pad (including reinforcement and excavation), and all other items necessary to complete this item of work.

The unit price bid for Bridge Approach Pavement Connector shall include tie bars, reinforcement and all other materials and items necessary to construct a complete connector of the type specified.

If pavement block-outs are required, the added reinforcement for pavement block-outs will not be paid for as a separate item, but shall be considered as included in the unit price bid for Pavement Fabric.



The unit price bid for Portland Cement Concrete Pavement, High-Early-Strength Portland Cement Concrete Pavement or Portland Cement Concrete Pavement (Hinge-Jointed) shall include the cost of any added thickness of pavement adjacent the railroad grade crossings. The reinforcement bars used in the slab adjacent to railroad grade crossings will be paid for according to Section 508. The bituminous plug will be paid for at the contract unit price per metric ton (ton) for BITUMINOUS CONCRETE BINDER COURSE, CLASS I, TYPE 2, as specified in Section 406.

When the contract requires the Contractor to furnish a profilograph, the cost of furnishing a California type profilograph or approved equivalent, providing for its maintenance and jobsite transportation, furnishing the profile scale and bump template, profilograph paper and recorder pens as outlined above will be paid for at the lump sum price for FURNISH PROFILOGRAPH.

The cost of furnishing a 5 m (16-ft.) straightedge and providing for its job site transportation shall be considered as included in the various items involved and no additional compensation will be allowed.

If a protective coat is applied other than at locations where corrective grinding

has been performed, it will be paid for at the contract unit price per square meter (square yard) for PROTECTIVE COAT, which price will be payment in full for cleaning the surface of the payement and appurtenances and for the 2 applications.

Removing and replacing curing and protective cover, when required, will be paid for according to Article 109.04.

## SECTION 421. CONTINUOUSLY REINFORCED PORTLAND CEMENT CONCRETE PAVEMENT



- **421.01 Description.** This work shall consist of constructing a continuously reinforced portland cement concrete on a prepared subgrade or subbase.
- **421.02 Materials.** Materials shall meet the requirements of Article 420.02. Wide flange beam shall meet the requirements of Article 1006.04 and be galvanized according to AASHTO M 111.
  - **421.03 Equipment.** Equipment shall meet the requirements of Article 420.03.

## **CONSTRUCTION REQUIREMENTS**



- **421.04 General.** Continuously reinforced concrete pavement shall be constructed according to the applicable portions of Articles 420.04 through 420.21 except as specified.
- **421.05 Placing.** This work shall be performed according to Article 420.07 with the following exception:

When the pavement is to be struck off and consolidated according to Article 420.11(a)(2), the concrete adjacent to both side forms shall be consolidated with a vibrator to eliminate all honeycomb or porous areas in pavement edges. The vibrator shall be inserted into the concrete and worked along the entire length of the forms before the finishing operations are initiated.

- **421.06 Strike Off of Concrete and Placement of Reinforcement.** This work shall be performed according to Article 420.09 with the following exceptions:
  - (a) Placement of Reinforcement. The pavement reinforcement shall be placed such that the reinforcement in the completed pavement will be at the location shown on the plans with a placement tolerance for individual bars of ±25 mm (±1 inch) horizontally and vertically.

Reinforcement bars shall be tied securely together. The minimum length of longitudinal bars shall be 9 m (30 ft.) except as required to establish the lap arrangement selected.

The Engineer will check the depth and lateral placement of the pavement reinforcement at such times and in such places as the Engineer may elect. No additional compensation will be allowed for replacing and refinishing concrete at inspection points.

Pavement reinforcement shall be supported on epoxy or plastic coated

## Continuously Reinforced Portland Cement Concrete Pavement

chairs at the depth below the pavement surface as indicated on the plans. The plastic chairs may be recycled plastic. The Contractor shall submit prints of shop drawings showing details of chairs and their spacing to the Engineer and obtain the Engineer's approval before any fabrication is begun.

The chairs shall possess the necessary rigidity and be spaced at intervals close enough to hold the reinforcement at the proper depth and position. However, the spacing of the chairs shall not exceed 900 mm (3 ft.) transversely or 1.2 m (4 ft.) longitudinally. The chairs shall be fabricated with sand plates.

Pavement reinforcement bars shall be assembled by fastening the longitudinal bars to the transverse bars with wire, clips, or other acceptable methods meeting the approval of the Engineer. The size and spacing of the bars shall be as shown on the plans. Welding of the longitudinal and transverse bars will not be permitted.

**421.07 Joints And Concrete Lug End Anchorages.** The longitudinal and transverse joints and lug end anchorages shall be constructed as specified in the contract according to Article 420.10 with the following exceptions:

- (a) Longitudinal Sawed Joints. The tie bars in longitudinal sawed joints shall be positioned on the prepared subbase prior to concrete placement and shall either be supported on approved assemblies or securely tied to the underside of the longitudinal bars of the pavement reinforcement.
- (b) Transverse Construction Joints. Transverse construction joints shall be made at the end of each day's run or when an interruption in the concreting operation of 30 minutes or more occurs, provided the length of pavement laid from the last joint is 4 m (12 ft.) or more and the distance from the construction joint to the nearest bar-lap is at least 1 m (3 1/2 ft.). Sections less than 4 m (12 ft.) in length shall be removed by the Contractor at his/her own expense.

The transverse construction joint shall be formed by means of a suitable split header board conforming to the cross section of the pavement, accurately set and securely held in place in a plane perpendicular to the surface of the pavement. The pavement reinforcement bars shall extend continuously through the split in the header board and shall be supported beyond the joint by metal chairs. The header board shall be kept clean and shall not be oiled. Any excess mortar material accumulated at the front of the paver shall be wasted and not incorporated into the pavement at the joint. Before paving operations are resumed, the header board shall be removed, any concrete or mortar that may have leaked through the holes or split in the header shall be chipped from the face of the joint and removed, all surplus concrete on the subgrade or subbase shall be cleared away, and any irregularities in the subgrade or subbase shall be corrected. The fresh concrete shall be deposited directly against the old and shall be consolidated with a hand vibrator inserted into the concrete and worked along the entire length of the joint. Transverse construction joints shall not be edged or sealed.

When internal vibration is used for concrete consolidation, the pavement areas adjacent to both sides of transverse construction joint shall receive additional consolidation from hand vibrators inserted into the concrete and the surface shall be refinished. These areas shall extend at least 3 m (10 ft.) from the joint.

- (c) Transverse Terminal Joint. When specified, transverse terminal joints shall be constructed at the ends of a construction section according to the details included in the plans. The concrete shall be either Class SI Concrete or Class PV Concrete. The pad shall be constructed to the same slope and cross section as the pavement and the entire top surface shall be given a smooth finish with a steel trowel. The concrete pad shall be completed and cured as specified in Article 1020.13 before the pavement and remainder of the transverse terminal joint is constructed.
- (d) Wide Flange Beam Terminal Joint. The sleeper slab shall be constructed of either Class SI Concrete or Class PV Concrete placed in a trench as shown on the plans. The sleeper slab shall be constructed to the same slope and cross section as the pavement. The top surface of the sleeper slab shall be given a smooth finish with a steel trowel on the pavement side of the steel beam and a rough finish on the terminal joint side. The sleeper slab shall be cured as specified in Article 1020.13(d)(1), except that membrane curing will not be permitted.

The chairs for the beams may be uncoated steel. When used, the uncoated chairs shall be at 1.8 m (6 ft.) centers, beginning 900 mm (3 ft.) from the end of the beam.

The concrete in the groove on the expansion side of the wide flange shall be carefully finished across the top and at the edges of the pavement to facilitate unrestrained pavement expansion.

- (e) Lug End Anchorages. The lugs shall be constructed in trench. Excavation for the trench shall be to the minimum dimensions shown on the plans. The use of forms will not be permitted. The lugs and the concrete pad above the lugs shall be constructed of either Class SI Concrete or Class PV Concrete and shall be cured as specified in Article 1020.13(d)(1) except that membrane curing will not be permitted. The surface of the concrete pad shall be finished rough and shall be free of any dust, dirt or other foreign material at the time the continuously reinforced concrete pavement is placed.
- **421.08 Final Strike Off, Consolidation and Finishing.** The final strike off, consolidation and finishing shall be performed according to Article 420.11 with the following exceptions:
  - (a) The vibrating impulse shall be applied in a manner to consolidate the concrete throughout its entire depth and width.
  - (b) Special care shall be taken to attain thorough consolidation of the concrete under and around the lapped bars to avoid segregation and honeycomb.
  - (c) The pavement vibrator shall not be allowed to operate for more than

## Continuously Reinforced Portland Cement Concrete Pavement

10 seconds while the machine is standing still. Only one pass of the vibratory equipment shall be made.

**421.09 Thickness Tolerance.** The tolerance in pavement thickness shall be according to Article 407.10, except that the width of a pavement unit shall be as specified in Article 420.18 and if any thin pavement is deficient in thickness by more than 10 percent is left in place, the Contractor will receive no compensation for the thin pavement. In addition, an amount equal to 4 times the contract cost of the thin pavement will be deducted from the compensation due the Contractor.

#### 421.10 Method of Measurement.

- (a) Contract Quantities. The requirements for the use of contract quantities shall conform to Article 202.07(a).
- (b) Measured Quantities. Continuously reinforced portland cement concrete pavement will be measured for payment in place and the area computed in square meters (square yards). The width will be the width of pavement as shown on the plans.

The quantity of reinforcement bars used for pavement reinforcement will be the computed square meters (square yards) of surface area of the pavement in which the pavement reinforcement is installed, and no allowance will be made for laps, splices or portions of bars not used. Expansion joints and extra reinforcement in the pavement over concrete pads, sleeper slabs and at construction joints will not be measured for payment but shall be included in the unit price bid for continuously reinforced portland cement concrete pavement.

When the plan width for subbase is extended for the slipform method, such extended subbase will not be measured for payment but shall be considered as included in the unit price bid for the item of subbase involved.

The pavement surfaces upon which the protective coat is applied, except where corrective grinding has been performed, will be measured for payment, and the areas computed in square meters (square yards).

**421.11 Basis of Payment.** This work will be paid for at the contract unit price per square meter (square yard) for CONTINUOUSLY REINFORCED PORTLAND CEMENT CONCRETE PAVEMENT and CONTINUOUSLY REINFORCED HIGH-EARLY-STRENGTH PORTLAND CEMENT CONCRETE PAVEMENT, of the thickness specified, and PAVEMENT REINFORCEMENT.

Bridge Approach Pavement and Bridge Approach Pavement Connector will be paid for as specified in Article 420.23.

Wide flange beam terminal joints will be paid for at the contract unit price each for WIDE FLANGE BEAM TERMINAL JOINT COMPLETE of the pavement width specified, which price shall include all excavation, portland cement concrete, reinforcing bars, structural steel, pavement, pavement reinforcement, stabilized subbase and all other appurtenances necessary to construct the wide flange beam terminal joint complete as shown on the plans.

Lug anchor systems will be paid for at the contract unit price each for LUG SYSTEM COMPLETE of the pavement width specified, which price shall include all excavation, portland cement concrete, reinforcement and all other appurtenances necessary to construct the lug system complete as shown on the plans. The continuously reinforced portland cement concrete pavement over the lugs will be paid for as specified above.

Transverse terminal joints will be paid for at the contract unit price each for TRANSVERSE TERMINAL JOINT COMPLETE of the pavement width specified, which price shall include the reinforced concrete pad (including excavation), header board, wood blocking and extended reinforcement beyond the end of the pavement.

If a protective coat is applied, it will be paid for at the contract unit price per square meter (square yard) for PROTECTIVE COAT, which price shall be payment for cleaning the surface of the pavement and appurtenances and for the 2 applications.

Removing and replacing curing and protective cover, if required, will be paid for according to Article 109.04.

When the contract requires the Contractor to furnish a profilograph, the profilograph and 5 m (16-ft.) straightedge will be paid for according to Article 420.23

## SECTION 422. PORTLAND CEMENT CONCRETE RAILROAD CROSSING

**422.01 Description.** This work shall consist of constructing a cast-in-place portland cement concrete railroad crossing constructed in 2 courses on a prepared subgrade.

The removal and replacement of ballast, rails, ties, tie plates and fastenings; the surfacing and lining of track to true line and grade; and the furnishing and placing of the inner guardrails will be executed by others without charge to the Contractor.

**422.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 - Materials:

	Item	Article/Section
(a)	Reinforcement Bars	1006.10
(b)	Portland Cement Concrete	1020
(c)	Bituminous Materials	1009.01, 1009.04, 1009.08
	Preformed Joint Filler	
(e)	Protective Coat	1023.01

**422.03 Equipment.** Equipment shall meet the requirements of the following Articles of Section 1100 - Equipment:

	Item	Article/Section
(a)	Concrete Mixers	1103.01
(b)	Batching and Weighing Equipment	
(c)	Vibrator	1103.17
(d)	Membrane Curing Equipment	1101.09(b)

## Portland Cement Concrete Railroad Crossing

#### CONSTRUCTION REQUIREMENTS

**422.04** Cooperation. The Contractor shall cooperate with the Railroad in order to eliminate undue delays to railroad traffic.



- **422.05 Composition of Concrete.** The requirements of Article 420.08 shall govern the mixing and placing of the concrete during cold weather.
- **422.06 Subgrade Preparation.** After the Railroad has removed or blocked up the existing rails and ties, and has removed and replaced the ballast, the Contractor shall tamp or roll the subgrade until compacted to a uniform density throughout, true to grade and cross section.
- **422.07** Forms and Form Setting. Side forms shall be of lumber of not less than 50 mm (2 inches) nominal thickness, or of steel of equal rigidity. They shall be held securely in place by stakes or braces with the top edges true to line and grade.
- **422.08 Placing and Finishing.** The subgrade shall be moistened just before the concrete is placed. While the tracks are blocked up or removed, the concrete for the lower slab shall be placed in successive batches for the entire width of the slab, tamped until all voids are removed, consolidated with a vibrator along the edges, and struck off to true line and even surface with floats and trowels. The final troweling shall be done with a steel trowel leaving a smooth, even surface. After the crossties have been reset and aligned and before the Railroad is allowed to relay the track in its final position, the Contractor shall apply one coat of Liquid Asphalt, (RC-70), to the top of the base slab. The concrete in the upper portion or top slab shall then be placed in successive batches for the entire width of the slab, tamped until all voids are removed, consolidated with a vibrator along the edges and ties, struck off to a true line and even surface, edged according to Article 420.11(d) and broomed according to the applicable portions of Article 503.17.
- **422.09 Adjustments.** In order to secure an even track surface, it may be necessary to correct for variations in thickness of the crossties by one of the following methods:
  - (a) Place the base slab approximately 15 mm (1/2 inch) lower than shown on the plans and provide a cement grout between the top of the base slab and the bottom of the ties; or
  - (b) The ties shall be placed as soon as practicable after the placing of the 200-mm (8-inch) base slab and the elevation adjusted as the ties are laid in the plastic concrete.
- **422.10 Bituminous Filler for Rails and Flangeways.** The bituminous material used to fill in around the rails and form the flangeways shall be a cold-lay sand-bituminous mixture meeting the requirements of the Engineer.

The cold-lay bituminous material used as the filler around the rails shall be laid only when the contact surfaces are dry. No mixture shall be laid when the air temperature is below 5 °C (40 °F.). Care shall be taken to prevent the bituminous mixture from becoming mixed with foreign materials. The contact surfaces of the rail and concrete shall be painted with a thin, uniform coating of Liquid Asphalt: RC-70 just before the bituminous cold-lay mixture is placed. The mixture shall be tamped

thoroughly into place to the elevation shown on the plans or as directed by the Engineer.

- **422.11 Protective Coat.** Linseed oil and petroleum spirits shall be applied according to applicable portions of Article 420.21.
- **422.12 Backfill.** After the concrete has been cured, the spaces along the edges of the crossing shall be backfilled to the required elevation with approved granular material. The material shall be compacted and the surface neatly trimmed or graded.
- **422.13 Disposal of Surplus Material.** Surplus or waste material resulting from the crossing construction operations shall be disposed of by the Contractor, at his/her own expense, according to Article 202.03.
- **422.14 Method of Measurement.** Portland Cement Concrete Railroad Crossing will be measured for payment in place and the area computed in square meters (square yards).

Reinforcement bars will be measured for payment in kilograms (pounds) as specified in Article 508.07.

**422.15 Basis of Payment.** This work will be paid for at the contract unit price per square meter (square yard) for PORTLAND CEMENT CONCRETE RAILROAD CROSSING, which price shall include furnishing and installing the preformed expansion joint filler, the cold-lay bituminous filler for rails and flangeways, and the granular backfill.

Reinforcement will be paid for according to Section 508.

The protective coat will not be paid for separately but shall be considered as included in the unit price bid for Portland Cement Concrete Railroad Crossing.

# SECTION 423. PORTLAND CEMENT CONCRETE DRIVEWAY PAVEMENT

- **423.01 Description.** This work shall consist of a portland cement concrete driveway pavement constructed on a prepared subgrade, according to requirements of Section 420 insofar as they apply.
- **423.02 Method of Measurement.** Portland cement concrete driveway pavement will be measured for payment in place and the area computed in square meters (square yards).
- **423.03 Basis of Payment.** This work will be paid for at the contract unit price per square meter (square yard) for PORTLAND CEMENT CONCRETE DRIVEWAY PAVEMENT, of the thickness specified.



## SECTION 424. PORTLAND CEMENT CONCRETE SIDEWALK

**424.01 Description.** This work shall consist of portland cement concrete sidewalk and sidewalk aprons constructed in one course on a prepared subgrade. This item shall apply to sidewalk and sidewalk aprons placed on earth or other subgrade, but shall not apply to sidewalk that is integrally a part of a structure.

**424.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 - Materials:

	Item	Article/So	ection
(a)	Portland Cement Concrete		1020
(b)	Preformed Expansion Joint Fille	r	1051

**424.03 Equipment.** Equipment shall meet the requirements of the following Articles of Section 1100 - Equipment:

	Item	Article/Section
(a)	Concrete Mixers	1103.01
(b)	Batching and Weighing Equipment	1103.02, 1103.03
(c)	Membrane Curing Equipment	1101.09(b)

### **CONSTRUCTION REQUIREMENTS**

- **424.04 Subgrade Preparation.** The subgrade shall be tamped or rolled until thoroughly compacted and at the proper line and grade as shown on the plans. At locations where sidewalk is constructed at entrances, the sidewalk shall be thickened to the thickness of the adjacent entrance or driveway pavement.
- **424.05** Forms. Side forms shall be of lumber of not less than 50-mm (2-inch) thickness or of steel of equal rigidity. They shall be held securely in place by stakes or braces, with the top edges true to line and grade. Forms for the sidewalk aprons shall be set so that the slab will have a uniform fall between the sidewalk proper and the curb grade.

At the Contractor's option, slipforming using equipment approved by the Engineer will be allowed.

**424.06 Placing and Finishing.** The subgrade shall be moistened just before the concrete is placed. The concrete shall be placed in successive batches for the entire width of the slab, struck-off, consolidated and finished to a true and even surface with floats and trowels. The final troweling shall be done with a wooden float, leaving an even surface. Steel trowels shall not be permitted. After the water sheen has disappeared, the surface shall be given a final finish by brushing with a whitewash brush. The brush shall be drawn across the sidewalk at right angles to the edges of the walk, with adjacent strokes slightly overlapping, producing a uniform, slightly roughened surface with parallel brush marks.

The surface shall be divided by grooves constructed at right angles to the centerline of the sidewalk. These grooves shall extend to 1/4 the depth of the sidewalk, shall be not less than 3 mm (1/8 inch) nor more than 6 mm (1/4 inch) in width, and shall be edged with an edging tool having a 6 mm (1/4 inch) radius. No slab shall be longer than 1.8 m (6 ft.) nor less than 1.2 m (4 ft.) on any one side,

unless otherwise ordered by the Engineer. The edges of the slabs shall be edged as described above.

- **424.07 Expansion Joints.** Expansion joints of the thickness specified below shall consist of preformed joint filler. The top of the joint shall be placed 6 mm (1/4 inch) below the surface of the sidewalk.
  - (a) 15-mm (1/2-Inch) Thick Expansion Joints. Expansion joints 15 mm (1/2 inch) thick shall be placed between the sidewalk and all structures such as light standards, traffic light standards, traffic poles and subway columns, which extend through the sidewalk.
  - (b) 20-mm (3/4-Inch) Thick Expansion Joints. Transverse expansion joints 20 mm (3/4 inch) thick shall be placed at intervals of not more than 30 m (100 ft.) in the sidewalk. Where the sidewalk is constructed adjacent to pavement or curb having expansion joints, the expansion joints in the sidewalk shall be placed opposite the existing expansion joints as nearly as practicable. Expansion joints shall also be placed where the sidewalk abuts existing sidewalks, between driveway pavement and sidewalk, and between sidewalk and curbs where the sidewalk abuts a curb.
- **424.08 Sidewalk Ramps.** Sidewalk accessibility ramps to the disabled shall be constructed of the type and at the locations shown on the plans in alignment with normal sidewalk and/or crosswalk and shall have sufficient curb length at the corner radius to prevent vehicular encroachment.

Sidewalk ramps at marked crossings shall be wholly contained within the markings, excluding any flared sides. The slope of the side flares shall be as shown on the plans.

Sidewalk ramps shall be constructed and cured as specified in this Section except that final texturing shall be accomplished with an expanded metal grate pressed into the plastic concrete and removed to form a diamond pattern as shown on the plans.

Sidewalk ramps shall be constructed to the same thickness as the adjacent sidewalk with a minimum thickness of 100 mm (4 inches) and shall be measured and paid for as specified for the item of sidewalk involved, and no additional compensation will be allowed.

- **424.09 Backfill.** After the concrete has been cured, the spaces along the edges of the sidewalk and ramps shall be backfilled to the required elevation with approved material. The material shall then be compacted until firm, and the surface neatly graded.
- **424.10 Disposal of Surplus Material.** Surplus or waste material resulting from the sidewalk construction operations shall be disposed of by the Contractor, at his/her own expense, according to Article 202.03.
- **424.11 Method of Measurement.** Portland cement concrete sidewalk and accessibility ramps will be measured for payment in place, and the area computed in square meters (square feet).

## Art. 424.12 Portland Cement Concrete Sidewalk

- **424.12** Basis of Payment. This work will be paid for at the contract unit price per square meter (square foot) for PORTLAND CEMENT CONCRETE SIDEWALK of the thickness specified, which price shall include all required expansion joints, special texturing, and variable height edge treatment at sidewalk ramps.
- | Earth excavation required will be paid for according to Section 202.

#### SECTION 440. REMOVAL OF EXISTING PAVEMENT AND APPURTENANCES

**440.01 Description.** This work shall consist of the removal and satisfactory disposal of all existing pavement, base and stabilized subbase, including resurfaced pavement; curb, gutter, and combination curb and gutter, including gutter inlets, outlets, and entrances; paved ditch, median, paved shoulders, driveway pavement, and sidewalk; bituminous surfaces in preparation for subsequent resurfacing; and the partial depth removal of concrete medians. The reference to "paved shoulders" in this Section shall include those shoulders constructed of bituminous and portland cement concrete.

### CONSTRUCTION REQUIREMENTS

**440.02 General.** All existing pavement, including surface courses, base courses, and stabilized subbases, and other appurtenances as listed above, which interfere with construction work shall be completely removed as shown on the plans or as directed by the Engineer. When portions of existing pavement and appurtenance are to remain in place, provisions shall be made for satisfactory transitions between replacements and the portions remaining in place. The Contractor shall form a perpendicular straight joint by full-depth machine sawing at the ends and all edges of portions to be removed to prevent surface spalling when the concrete is broken out. Any damage done to the existing pavement or appurtenance to remain in place shall be repaired or removed and replaced by the Contractor at his/her own expense, as directed by the Engineer.

It shall be the responsibility of the Contractor to determine the thickness of the existing pavement structure, including overlays, and other appurtenances to be removed, and the extent to which they are reinforced. No additional compensation will be allowed because of variations from the assumed thickness(s) or from the thickness(s) shown on the plans, or for variations in the amount of reinforcement.

Gutter removal shall include the complete removal of all inlets, outlets and entrances that are contained within the limits of the designated removal. The removal of outlets shall include the entire discharge trough and end curtain wall for trough type outlets and the concrete box and outlet pipe for drop box type outlets.

Paved ditch removal shall include the complete removal of all anchor walls and cut-off walls that are contained within the limits of the designated removal.

Any excavation made by the Contractor for the removal shall be replaced. The excavated space shall be filled with material satisfactory to the Engineer and placed according to Section 205 by and at the expense of the Contractor.

**440.03 Bituminous Surface Removal for Subsequent Resurfacing.** The machine for the removal of bituminous surfaces in preparation for subsequent resurfacing shall be a self-propelled planing machine or a self-propelled milling machine.



The planning machine shall have a wheel base width of not less than 3 m (10 ft.) and shall be capable of heating, planing and cutting the old surface and depositing the cuttings into a windrow in one or more passes.

## Art. 440.03 Removal of Existing Pavement and Appurtenances

The milling machine shall be capable of cold milling and cutting the existing surface and depositing the cuttings into a windrow or directly loading the cuttings into a truck. It shall be capable of removing a layer of bituminous material at least 1.8 m (6 ft.) in width and 40 mm (1 1/2 inches) in depth in a single pass. When the width of surface removal is less than 1.8 m (6 ft.), machines less than 1.8 m (6 ft.) wide will be permitted except that the area milled shall not be wider than the width of the work specified on the plans. The milling machine shall be capable of accurately and automatically establishing profile grades by reference from either the existing pavement or from an independent grade control to provide a milled surface within a tolerance of 5 mm (3/16 inch) in 5 m (16 ft.) when tested with a 5 m (16 ft.) straightedge. It also shall have an effective means for removing all loose and excess material from the surface and for preventing any dust resulting from the operation from escaping into the air.

The existing bituminous surface shall be removed to the depth specified on the plans. The temperature at which the work is performed, the nature and condition of the equipment, and the manner of performing the work shall be such that the planed or milled surface is not torn, gouged, shoved or otherwise damaged by the planing or milling operation. Sufficient cutting passes shall be made so that all irregularities or high spots are eliminated to the satisfaction of the Engineer. When tested with a 5 m (16 ft.) straightedge, the planed or milled surface shall have no surface variations in excess of 5 mm (3/16 inch).

Removing the existing bituminous surface to the required depth adjacent to structures in the pavement surface such as drain castings and utility covers shall be accomplished in a manner satisfactory to the Engineer using either machine or hand methods.

- **440.04 Median Removal Partial Depth.** The equipment used for median removal partial depth shall be a self-propelled mobile unit capable of removing the concrete to the depth specified by a cold milling process utilizing tungsten carbide cutting tools. The equipment shall be capable of accurately controlling the elevation and cross slope of the removal, and shall have an effective means of removing the material from the median and of preventing dust from escaping into the air.
- **440.05** Removal and Replacement. Except as provided for in Section 441 or when otherwise specified, whenever the plans indicate that the existing pavement structure and/or appurtenances are to be removed and replaced, the removal and the replacement shall be performed and paid for as separate items. Removal shall be according to the requirements specified herein. Replacement shall be according to Sections of these Specifications that pertain to the specific item or items being replaced.
- **440.06 Disposal of Material.** Materials resulting from the removal of existing pavement and appurtenances as herein specified shall be disposed of as specified in Article 202.03.

### 440.07 Method of Measurement.

- (a) Contract Quantities. The requirement for use of contact quantities shall be according to Article 202.07(a).
- (b) Measured Quantities. Pavement removal and driveway pavement removal shall be measured for payment in place and the area computed in square

meters (square yards).

Bituminous surface removal for subsequent resurfacing will be measured for payment in place and the area computed in square meters (square yards) for each specified increment thickness of material removed.

Curb removal, gutter removal, combination curb and gutter removal and paved ditch removal will be measured for payment in meters (feet). The measurement for curb removal and combination curb and gutter removal will be made along the face of the curb. Paved ditch removal will be measured along the flow line of the paved ditch. Gutter removal will be measured along the edge of the gutter which is in actual contact with the edge of the pavement.

Sidewalk removal, median removal and median removal partial depth will be measured for payment in place and the area computed in square meters (square feet).

Removal of any of the items listed above outside the designated limits as shown on the plans or as directed by the Engineer will not be measured for payment. The removal of base and stabilized subbase will not be measured for payment as separate items, but shall be considered as included in the contract unit price for Pavement Removal, and no additional compensation will be allowed.

440.08 Basis of Payment. This work will be paid for at the contract unit price per square meter (square yard) for PAVEMENT REMOVAL, DRIVEWAY PAVEMENT REMOVAL and PAVED SHOULDER REMOVAL; at the contract unit price per square meter (square yard) for BITUMINOUS SURFACE REMOVAL of the thickness specified; at the contract unit price per meter (foot) for CURB REMOVAL, GUTTER REMOVAL, COMBINATION CURB AND GUTTER REMOVAL, and PAVED DITCH REMOVAL; and at the contract unit price per square meter (square foot) for SIDEWALK REMOVAL, MEDIAN REMOVAL and MEDIAN REMOVAL PARTIAL DEPTH. The contract unit price for Pavement Removal shall include removing and disposing of the entire pavement structure.

The contract unit price for Gutter Removal shall include removing all inlets, outlets and entrances, including concrete boxes and outlet pipes, and discharge troughs and end curtain walls even though they may partially extend beyond the limits of measurement.

The contract unit price for Pavement Removal shall include removing and disposing of the entire pavement structure, including surface, base, and any stabilized subbase.

The contract unit price for Paved Ditch Removal shall include removing any and all anchor walls and cut-off walls encountered.

## **SECTION 441. PAVEMENT REPLACEMENT**

**441.01 Description.** This work shall consist of the removal and replacement, and any necessary excavation and embankment of all surface, base course, and subbase as shown on the plans.

Where all of the pavement, including subbase, base and surface course, is to be replaced, the item will be specified as "Pavement Replacement". If only surface course, binder course, cushion and joint filler is to be replaced, the item will be specified as "Pavement Replacement - Surface Course".

The term "excavation" or "embankment" as used in this Article refers only to that necessary for the preparation of the subgrade, where the "Pavement Replacement" is full depth.

**441.02 Materials.** Materials shall meet the requirements of Section 1000 - Materials.

### CONSTRUCTION REQUIREMENTS

**441.03 General.** All base, surface courses or subbase removed shall be restored to the original cross section.

The elevation of the surface of the replaced surface course shall not vary more than 3 mm (1/8 inch) from the elevation of the surface of the adjoining surface course. The subgrade in the case of surface, base course and subbase removal, and the cushion or filler on the base course in the case of surface course removal, shall be adjusted so that this result will be obtained.

Pavement damaged by reason of construction operations outside of the working limit of 600 mm (2 ft.) from the form line specified shall be replaced by the Contractor at his/her own expense.

- **441.04 Portland Cement Concrete Base and Surface Courses.** Portland cement concrete base or surface courses or natural cement concrete base or surface courses which are removed shall be replaced with portland cement concrete base or surface courses meeting the requirements of Sections 353 and 420, respectively, except that hand methods of consolidating and finishing will be permitted.
- 441.05 Brick, Granite Block and Wood Block Surface Courses. Brick, granite block or wood block surface courses which are removed shall be replaced if specified on the plans or directed by the Engineer. Whole sound brick, granite blocks or wood blocks taken from the original surface course shall be used in the replacement. If additional brick, granite blocks or wood blocks are required, the Contractor shall furnish a similar type and size to those which are being replaced. Brick, granite block or wood block surface course shall be laid on a sand or limestone screenings cushion approximately 25 mm (1 inch) thick, and shall have the joints filled with asphalt. The surface or base, may be restored to the proper elevation by use of an approved compacted bituminous material or air-entrained portland cement concrete according to Article 441.04.
- **441.06 Bituminous Surface and Binder Courses.** Bituminous surface and binder courses which are removed shall be replaced by an equal thickness of bituminous materials meeting the requirements of either Section 405 or 406. The type used shall be that which closely conforms to the type which was removed, and shall be approved in writing by the Engineer.
- **441.07** Gravel or Crushed Stone Base and Surface Courses. Gravel or crushed stone base and surface courses which are removed shall be replaced by an equal thickness of materials meeting the requirements of Section 351 or Section 402.

The type used shall be that which closely conforms to the type which was removed and shall be approved in writing by the Engineer.

- **441.08** Base and Subbase Replacement. All granular or stabilized base and subbase which are removed shall be replaced with an equal compacted thickness of material which closely conforms to the original material removed and shall be compacted to the density requirements of the granular or stabilized base and subbase removed.
- **441.09 Disposal of Surplus Material.** Surplus or waste material resulting from the removal and replacement operations shall be disposed of by and at the expense of the Contractor according to Article 202.03.
- **441.10 Method of Measurement.** Pavement Replacement and Pavement Replacement Surface Course, will be measured in place, and the area computed in square meters (square yards). Pavement or surface course damaged by reason of construction operations outside of the working limit of 600 mm (2 ft.) from the form line specified will not be measured for payment.
- **441.11 Basis of Payment.** This work will be paid for at the contract unit price per square meter (square yard) for PAVEMENT REPLACEMENT or PAVEMENT REPLACEMENT SURFACE COURSE, which prices shall include any required earth excavation or embankment.



### **SECTION 442. PAVEMENT PATCHING**

**442.01 Description.** This work shall consist of the removal of the existing pavement, the necessary excavation and the replacement with the class and type of patch specified at designated locations.

This work will be classified as follows:

Class A Patches: Pavement Removal and Continuously

Reinforced Portland Cement Concrete Replacement

Class B Patches: Pavement Removal and

Portland Cement Concrete Replacement

Using Dowels or Tie Bars

Class C Patches: Pavement Removal and Portland

Cement Concrete Replacement

Class D Patches: Pavement Removal and Bituminous Concrete

Replacement

Pavement Patching: Contractor's Option of Class C or Class D

For each of the above classifications, the work on a lane width or less shall be further quantified by size as follows:

Type I Less than  $5 \text{ m}^2$  (5 sq. yds.)

Type II 5 m<sup>2</sup> (5 sq. yds.) or more, but less than 15 m<sup>2</sup> (15 sq. yds.) Type III 5 m<sup>2</sup> (15 sq. yds.) or more, but less than 20 m<sup>2</sup> (25 sq. yds.)

Type IV  $20 \text{ m}^2$  (25 sq. yds.) or more

### Pavement Patching

**442.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 - Materials:

	Item	Article/Section
(a)	Portland Cement Concrete (Note 1)	1020
(b)	Concrete Reinforcement Bars, Fabric and Strand	1006.10
(c)	Dowel Bars, Expansion Joint Assembly	
	and Contraction Joint Assembly (Note 2)	1006.11
(d)	Preformed Expansion Joint Filler	1051.08, 1051.09
(e)	Preformed Fiberboard	1051.04
(f)	Bituminous Materials 1009.01 - 1009.05,	1009.07, 1009.08
(g)	Non-shrink Grout	1024.01
(h)	Poured Joint Sealer	1050.02
(i)	Backer Rod (Note 3)	
(j)	Material for Forming Joint Grooves (Note 4)	
(k)	Chemical Adhesive	1027.01

- Note 1. When patching ramp pavements and 2-lane pavements with 2-way traffic, the special patching mixture specified in Article 1020.05(g)(2) shall be used for Class A, Class B and Class C patching. For all other pavements, either the early strength patching mixture specified in Article 1020.05(g)(1) or the special patching mixture shall be used, at the Contractor's option, for Class A, Class B and Class C patching.
- Note 2. For Class B patches, the dowel bars shall be painted round bars conforming to the requirements of AASHTO M 227M (M 227), grades 70 through 80. The dowel bars may be painted with red oxide or zinc chromate one-coat shop paint.
- Note 3. The backer rod shall be a closed-cell, plastic foam rod compatible with the sealant and the elevated temperatures of joint sealant application.
- Note 4. Material for joint forms shall be suitable for forming the sealant reservoir to the width and depth as shown on the plans and of sufficient strength to retain its shape during concrete placement.

**442.03 Equipment.** Equipment shall meet the requirements of the following Articles of Section 1100 - Equipment:

	Item Article	e/Section
(a)	Self-Propelled Rollers	1101.01
(b)	Vibratory Rollers (Note 1)	
(c)	Side Forms (Note 2)	1103.05
(d)	Mixer or Truck Agitator (Note 3)	
(e)	Batching and Weighing Equipment (Note 4) 1103.02,	
(f)	Hot-Mix Plant	1102.01
(g)	Concrete Saw (Note 5)	
(h)	Wheel Saw (Note 6)	
(i)	Equipment and Devices for Removing Old Concrete Slabs (Note 7)	
(j)	Drilling Machine (Note 8)	
 (k)	Miscellaneous Equipment	
(l)	Membrane Curing Equipment	1101.09
	Heating Equipment for Joint Sealant (Note 9)	

- Note 1. The vibratory rollers and tampers shall meet the approval of the Engineer.
- Note 2. Wood forms will be permitted. The depth of form shall be plank width, the commercial dimension which equals the pavement thickness shown on the plans or the next larger commercial dimension.
- Note 3. Batch type mixer having a rated capacity of not less than 0.3 m<sup>3</sup> (10 cu. ft.) may be used. Chute delivery will be permitted.
- Note 4. Where the nominal production does not exceed 40 m<sup>3</sup> (50 cu. yds.) per day, the requirement for overhead bins and weighing hoppers completely suspended and hanging freely from the scales may be waived. Any other method for loading and weighing the aggregates must be approved by the Engineer.
- Note 5. The concrete saw shall be equipped with a diamond blade of sufficient size to saw pavements full-depth and be capable of accurately maintaining cutting depth.
- Note 6. The wheel saw shall be equipped with carbide-tipped rotating cutters and be capable of accurately maintaining cutting depth.
- Note 7. As approved by the Engineer.
- Note 8. The machine used for drilling the holes in the face of the existing pavement shall be capable of drilling the size and depth of holes as shown on the plans. The machine shall be equipped with a positive stop to control the depth of hole. During use, the stop shall be calibrated at least once a day. A drill support system using the pavement surface as a reference shall be required to assure hole alignment at mid-depth of pcc pavement. Hand held tools will not be allowed.
- Note 9. The heating equipment shall be an indirect heating type with positive temperature control, mechanical agitation and recirculating pumps.

## **CONSTRUCTION REQUIREMENTS**

- **442.04 Keeping Road Open to Traffic.** The road shall be kept open to traffic according to Article 701.05(e).
- **442.05 Pavement Removal.** The pavement shall not be scored with a concrete saw or jackhammers more than 3 days prior to when it will be broken except when the pavement is closed to traffic. The pavement shall not be scored with a wheel saw more than one day prior to when it will be broken except when the pavement is closed to traffic.

If a wheel saw is used to score the pavement or areas of the pavement have been removed for purposes of cutting marginal bars and the pavement will be open to traffic, the cuts shall be filled with either full-depth cold bituminous mix meeting the approval of the Engineer or compacted granular material with a 50-mm (2-inch) minimum cap of cold bituminous mix meeting the approval of the Engineer. The cuts shall be constantly maintained so that they will not be a hazard to traffic.

Any drainage mat or pipe underdrains damaged during patching operations shall be repaired or replaced by the Contractor at his/her own expense.

Materials resulting from the removal of the existing pavement and unsuitable and unstable materials shall be disposed of according to Article 202.03.

The scoring and removal of pavement for the various classes of patches shall be as follows:

(a) Class A Patches. Two transverse saw cuts shall be made perpendicular to the centerline at each end of the patch except that the saw cuts may be skewed slightly if necessary to maintain a minimum distance of 450 mm (18 inches) from the end of the patch to the nearest transverse crack in the pavement to remain in place. When approved by the Engineer, this minimum distance may be reduced to 150 mm (6 inches) in areas of close crack spacing where the pavement otherwise appears to be sound. The interior saw cut shall be made at the location that will provide the proper length of exposed existing steel as shown on the plans and shall be either full-depth or to a depth which will completely sever the longitudinal reinforcement. The longitudinal edges of the patch shall be formed by full-depth saw cuts. Patches one-half lane width or full lane width will be permitted. Saw cut extensions into pavement which is to remain in place will not be permitted. All outlining and interior saw cuts shall be made with an approved concrete saw. After the interior saw cuts have been made, an approved wheel saw may be used to make pressure relief cuts or intermediate cuts to reduce the pavement length to a size that accommodates removal and hauling operations, at the Contractor's expense. The wheel saw cutting operations shall be controlled to limit subbase penetration to a maximum of 15 mm (1/2 inch).

The shoulder between the full-depth saw cut and the pavement edge shall be removed using a hand held hammer and hand tools prior to pavement removal. If available, the Contractor may use an approved wheel saw to make the shoulder cut and removal.

When the patch is adjacent to a pcc shoulder, a saw cut shall be made at the shoulder-pavement joint sufficiently deep to sever the tie bars. A second full-depth saw cut shall be made in the pavement a minimum of 100 mm (4 inches) from the edge of the shoulder. The pavement between the full-depth saw cut and the shoulder edge shall be removed using a hand held hammer and hand tools prior to removal of the remaining pavement.

The pavement between the interior saw cuts shall be removed by lifting. Sufficient care shall be taken to minimize subbase disturbance and prevent spalling of the pavement that is to remain in place. Any subbase material disturbed during pavement removal operations or determined unsuitable by the Engineer shall be removed and replaced with patch material.

If the Engineer determines that the concrete has deteriorated to the extent that it is not practical to lift, the pavement may be broken into small pieces and removed. The breaking equipment shall not transfer an impact energy greater than 4000 J (3000 foot-pounds) per blow to the pavement surface.



The concrete in the splicing area, between the interior and outer saw cuts,

shall be removed using hand held hammers and hand tools. Care shall be taken to prevent underbreaking of the concrete to remain in place. The face of the concrete below the partial-depth saw cut shall be inclined slightly into the patch. The reinforcing steel in the splicing area shall not be bent to aid in removal of the concrete. If more than 10 percent of the reinforcing steel in the splice area is damaged due to the Contractor's operations, the patch shall be lengthened at his/her own expense to provide the required steel exposure for splicing. If less than 10 percent of the existing lap steel is damaged, it may be repaired by welding in lieu of lengthening the patch. No welding will be permitted on the splices between the existing steel and the new steel.

Should the Contractor's operations cause a spall having a width or depth greater than 25 mm (1 inch) in the pavement to remain in place or cause excessive shattering or underbreaking of the existing slab to remain in place, a new saw cut shall be made, at the Contractor's expense, extending the patch to remove the spall or underbreaking. After pavement removal, the pavement structure will be inspected by the Engineer to determine if it is sufficiently sound. If determined unsound, the Contractor shall extend the patch as directed by the Engineer.

The existing reinforcement steel shall be observed during the removal process to determine if there is any excess rusting or evidence of steel distress. Deteriorated steel will not be permitted in the splice area. The Engineer may require lengthening of the patch.

(b) Class B Patches. Two transverse saw cuts outlining the patch shall be straight and perpendicular to the centerline, with a tolerance of 50 mm (2 inches) in 3.6 m (12 ft.). Saw cut extensions into pavement which are to remain in place will not be permitted. All saw cuts shall be made with an approved concrete saw (except as outlined below). Concrete not sawed full-depth shall be removed with hand tools. Only full lane width patches will be permitted.

When the patch is adjacent to a bituminous shoulder, a full-depth saw cut shall be made in the shoulder a minimum of 100 mm (4 inches) from the edge of the pavement or at such width as to facilitate forming. The shoulder between the full-depth saw cut and the pavement edge shall be removed with a hand held hammer and hand tools prior to pavement liftout.

When the patch is adjacent to a pcc shoulder, a saw cut shall be made at the shoulder-pavement joint sufficiently deep to sever the tie bars. A second full-depth saw cut shall be made in the pavement a minimum of 100 mm (4 inches) from the edge of the shoulder. The pavement between the full-depth saw cut and the shoulder edge shall be removed using a hand held hammer and hand tools prior to removal of the remaining pavement.

The Contractor may use an approved wheel saw to make the shoulder cut and removal, and to make pressure relief cuts or intermediate cuts to reduce the pavement length to a size that accommodates removal and hauling operations, at the Contractor's expense. The wheel saw cutting operations shall be controlled to limit subbase penetration to a maximum of 13 mm (1/2 inch). Wheel saw cuts shall be made after concrete sawing

outlining patch boundaries unless the wheel saw cuts are at least 450 mm (18 inches) inside the transverse patch boundaries. Should the Contractor be unable to conform to the requirements specified herein, the Engineer will withdraw approval of this alternative.

The pavement shall be removed by lifting. If the Engineer determines that the concrete has deteriorated to the extent that it is not practical to lift, the pavement may be broken into small pieces and removed. Breaking operations shall start adjacent to the removed wedge or the alternate wheel saw cut. The breaking equipment shall not transfer an impact energy greater than 4000 J (3000 foot-pounds) per blow to the pavement surface.

Care shall be taken to prevent subbase disturbance and spalling of the pavement which is to remain in place. Should the Contractor's operations cause a spall having a width or depth greater than 25 mm (1 inch), a new saw cut shall be made extending the patch to remove the spall, at the Contractor's expense. After slab removal, the existing pavement structure will be inspected by the Engineer to determine if it is sufficiently sound. If determined unsound, the Contractor shall extend the patch as directed by the Engineer. Any subbase material that is disturbed during pavement removal operations or determined unsuitable by the Engineer shall be removed and replaced with patch material.

Resawing of patch boundaries to remove spalls that exceed a width or depth of 25 mm (1 inch) will not be required when the patching is being performed to prepare the existing pavement for bituminous resurfacing.

(c) Class C Patches. Standard reinforced concrete pavement shall be scored with a concrete saw to a depth which severs the reinforcement. If the Contractor elects, he/she may saw full depth to alleviate spalling and replacement as specified in Article 442.05(a).

Non-reinforced concrete pavement shall be scored with jackhammers or other equipment approved by the Engineer. The scoring shall be at least 150 mm (6 inches) from the marked face of the patch. Marginal bars and tie bars shall be cut in a manner satisfactory to the Engineer.

As an alternate, the Contractor may use an approved wheel saw to score the pavement full-depth on either standard reinforced or non-reinforced pavement. Should the wheel saw damage the pavement and/or reinforcement which are to remain in place, the Engineer will withdraw approval of this alternate.

The existing pavement shall be removed as shown on the plans. Ends of the patch need not be squared but may follow the existing cracks, provided angles smaller than those shown on the plans do not result.

If the patch is not scored with a concrete saw or wheel saw, the ends of the patch shall be hand trimmed with hand held hammers or other tools or equipment approved by the Engineer. The general plane of the cut face shall not deviate more than 40 mm (1 1/2 inches) from vertical. Abrupt breaks or deviations from the plane of the cut face sufficient to induce spalling in either the top or the bottom surface of the pavement will not be

permitted.

Should the Contractor's operations cause a spall having a width or depth greater than 25 mm (1 inch), the patch shall be extended to remove the spall, at the Contractor's expense, except that this extension will not be required when the patching is being performed to prepare the existing pavement for bituminous resurfacing.

Equipment and methods used for removing old pavement shall be such as to prevent cracking, shattering or spalling of the pavement remaining in place. Breaking equipment shall not transfer an impact energy greater than 4000 J (3000 foot-pounds) per blow to the pavement surface.

After breaking and removal of the existing pavement, any areas of the subbase which are below the required elevation of the finished subbase, shall be built up to grade at the Contractor's expense, with satisfactory compacted granular material, concrete or compacted bituminous material.

Tie bars extending across the longitudinal joint, or such portion as may be exposed in the area of the patch, shall be cut approximately at the face of the pavement which is to remain in place, or they shall be removed. Marginal bars shall be cut close to the face of the pavement which is to remain in place.

(d) Class D patching shall be according to Article 442.09.

**442.06 Pavement Replacement.** Class A, Class B and Class C patches shall conform to the standard details and cross section included in the plans, and the work shall conform to the applicable portions of Section 420, with the following exceptions:

- (a) Placing Reinforcement and Dowel Bars.
  - (1) General. The reinforcement shall be as shown on the plans. Patches 6 m (20 ft.) or longer shall be tied to the adjacent lane of existing pavement, pcc shoulders, and curb and gutter with No. 20 (No. 6) transverse tie bars, 600 mm (24 inches) long, embedded 200 mm (8 inches) at 610 mm (24 inch) centers according to Article 420.10(b), except the cost of the anchors ties shall be considered as included in the contract unit price for patching and no additional compensation will be allowed.
  - (2) Class A Patching. Half-lane patches 6 m (20 ft.) or longer shall be tied to the adjacent lane of existing pavement, PCC shoulders, and curb and gutter with No. 20 (No. 6) 600 mm (24 inches) long, embedded 200 mm (8 inches) at 610 mm (24 inch) centers according to Article 420.10(b), except the cost of the ties shall be considered as included in the contract unit price for patching and no additional compensation will be allowed. The Contractor shall tie the steel together, using at least 2 secure ties for each lap splice. The details shall be as shown on the plans.

Should an existing lap splice be encountered in the patch slice area, the Contractor shall construct the new splice by tying both of the exposed reinforcement bars to the new reinforcement bar.

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Reinforcement steel shall be placed and supported on chairs according to Article 421.06 such that uniform unsupported lengths not exceeding 1.2 m (4 ft.) are provided. In such cases where an uneven subbase hinders maintenance of a placement tolerance of  $\pm$  25 mm (1 inch) vertically, portland cement concrete, sand-cement grout, or bituminous hot mixture shall be used to adjust the chair height to allow the reinforcement to be placed within the specified tolerances.

When the existing reinforcement is fabric, the longitudinal reinforcement bars shall be the same size and spacing as the existing longitudinal reinforcement.

(3) Class B Patching. Dowel and tie bar holes shall be drilled as shown on the plans, and parallel to the grade and centerline of the pavement with a tolerance of 3 mm (1/8 inch) in 300 mm (12 inches). The drilling operation shall not crack or spall the pavement.

Immediately prior to grouting the dowel bars or tie bars, the holes shall be thoroughly cleaned of drilling debris. Dust and debris shall be blown from the joint or crack with a power brush/blower or with compressed air. If compressed air is used, the pneumatic tool lubricator must be bypassed and a filter installed on the discharge valve to keep water and oil out of the lines. The dowel bars shall be clean and free from rust.

An approved chemical adhesive shall be used as the anchoring material for dowel bars. At the Contractor's option, either an approved non-shrink grout or chemical adhesive shall be used as the anchoring material for tie bars.

The grout or chemical adhesive shall be of a consistency such that the dowel or tie bar may be easily inserted into the hole with flow completely surrounding the bar, and without appreciable runout of grout or chemical adhesive after the bar is fully inserted. consistency of the grout should be thicker than the consistency recommended by the manufacturer's directions). The grout or chemical adhesive shall be injected to the back of the hole to eliminate air pockets prior to inserting the bar. The quantity of material used shall be such that the grout or chemical adhesive is dispersed along the entire length of the bar and voids are completely filled. After the material has been positioned at the back of the hole, the bar shall be fully inserted, using a back-and-forth twisting motion, leaving the proper length exposed as shown on the plans. If it is necessary to use a hammer to aid in seating a dowel, the exposed end of the dowel shall be protected with a wood block.

Immediately prior to placing the concrete, the exposed ends of dowel bars shall be cleaned and lightly oiled.

Class B patches Type III or Type IV shall be reinforced with pavement fabric according to the details shown on the plans. The reinforcement shall be placed at 90 mm  $\pm 25$  mm (3 1/2 inch  $\pm 1$  inch) below the final finished patch surface elevation according to Article 420.09, except



not be permitted.

Hinge jointed pavement shall be patched according to the details shown on the plans and as specified for Class B patches, except that if the area to be patched does not contain a contraction joint, only the leave end of the patch shall be dowelled and pavement fabric reinforcement shall not be used. The traffic approach end of patches in areas not containing a contraction joint shall be tied. Patches that are 14 m (45 ft.) or more in length shall have sawed contraction and hinge joints constructed according to the applicable requirements of Article 420.10 at 4.5 m (15-ft.) maximum intervals and shall be in prolongation with joints or cracks in the adjacent lane whenever possible. Patches 4.5 m (15 ft.) or longer shall be tied to the adjacent lane of existing pavement, pcc shoulders, and curb and gutter with No. 20 (No. 6) transverse tie bars, 600 mm (24 inches) long embedded 200 mm (8 inches) at 610 mm (24 inch) centers according to Article 420.10(b), except the cost of the ties shall be considered as included in the contract unit price for patching and no additional compensation will be allowed.

- (4) Class C Patching. When the patched pavement is not to be resurfaced, transverse contraction joints shall be formed on 4.5 m (15 ft.) to 6 m (20 ft.) centers by sawing in all Class C patches that are 6 m (20 ft.) or more in length. They shall be placed in prolongation with joints or cracks in the existing slab whenever possible.
- (b) Replacing Full Width Pavement. Unless through traffic is detoured, full width pavement shall be replaced in 2 or more operations. When replacing adjacent lanes in one operation, the longitudinal joint down the lane line shall be a sawed longitudinal joint as specified in Article 420.10, except that tie bars shall be included only for Type A, Type B, and Type C patches that are 6 m (20 ft.) or more in length. When full-width pavement is replaced in 2 or more operations, a form shall be installed along the laneline by one of the following methods:
  - (1) Method 1. Whenever practicable, an approved form, not less than 6 mm (1/4 inch) in thickness, shall be set along the longitudinal joint when placing the patching in the first half width. The depth of this form shall be equal to the thickness of the new pavement being placed, or as close thereto as standard lumber measurements will allow. No pavement in the lane open to traffic shall be removed to permit setting the form, and the form shall remain in place until the existing pavement in the opposite half width is removed.
  - (2) Method 2. When the existing pavement in the opposite half width is so broken or disintegrated that it is not feasible to use Method 1, a wood form shall be set along the longitudinal joint when placing the patch in the first half width, except that a metal form may be used for Type III patches when mechanical finishing is employed. Only sufficient concrete shall be removed from the lane open to traffic to permit setting the form. As soon as permissible after the concrete is poured, the form shall be removed, and the trench occupied by the form shall be filled immediately with compacted granular material,

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which shall be constantly maintained in such a manner that it will not be a hazard to traffic.

# (c) Forms.

- Side forms will be required.
- (2) For Class B Patches, a bond breaker of 6 mm (1/4 inch) fiber board, or other material approved by the Engineer, shall be placed flush with the surface at the pavement centerline for the full length and depth of the patch. If the centerline sealant reservoir is to be formed, that part of the bondbreaker may be replaced by the joint reservoir form.
- (d) Ready Mix Concrete. Non-agitating trucks will not be permitted for transporting the mixed concrete, except in specific cases, and then only upon written permission of the Engineer.
- (e) Concrete Placement. For Class A, Class B and Class C Patches, concrete shall be placed according to Article 420.07 and governed by the limitations set forth in Article 420.08, except that the maximum temperature of the mixed concrete immediately before placing shall be 35 °C (96 °F.), the required use of an approved retarding admixture when the plastic concrete reaches 30 °C (85 °F.) shall not apply, and placing of the special patching mixture, when its use is required, shall be only when the air and ground temperatures in the shade are at or above 15 °C (55 °F.) and the temperature for the next 8 hours is expected to remain above 5 °C (40 °F.).

In the case of Class A Patches, if the subbase and subgrade material have been disturbed and/or removed in excess of plan pavement thickness plus subbase thickness or more from the surface of the pavement, the concrete shall be placed in lifts and separated by a bond breaker. The elevation of the bottom lift shall be level with the top of the subbase. A thin coating of rapid setting asphalt emulsion or thick coating of Type III curing compound shall be applied to the surface of the bottom lift. Care shall be taken to avoid coating the vertical faces of the existing pavement or any reinforcement. The remainder of the concrete shall be placed after the asphalt emulsion or curing compound has sufficiently cured but not before at least 1 day after placement of the bottom lift.

(f) Consolidating and Finishing. The concrete shall be consolidated by internal vibration. Special attention shall be given to consolidating the concrete around the corners, edges, dowel bars, tie bars and reinforcement.

For Class A and Class B, the surface of the patch shall be struck off with 2 passes of a vibratory or rolling screed as approved by the Engineer. For Class C Patches, finishing may be performed by either machine or hand methods. For repairs 4 m (12 ft.) or less in length, the screed shall be placed parallel to the edge of pavement. For repairs over 4 m (12 ft.) in length, the screed shall be placed perpendicular to the edge of pavement. In striking off, the template shall be moved forward with a combined longitudinal and transverse shearing motion, moving always in the direction in which the work is progressing and manipulated so that neither edge is raised during the striking off process. A slight excess of concrete shall be

kept in front of the cutting edge at all times during the striking off operation.

After strike off, but while the concrete is still plastic, the surface of the concrete shall be tested for trueness by means of a 3-m (10-ft.) straightedge according to Article 420.11(c).



For Class A and Class B patches which will not be overlaid, the surface shall be stamped with the current year approximately 300 mm (1 ft.) from the outer edge of the lane.

- (g) Brooming and Edging. When patching pavements which have not been overlayed, the final finish shall match the surrounding pavement. When patching pavements which have been overlayed, the surface of the concrete shall be textured with a broom finish applied transversely to the pavement centerline. The texturing operation shall be executed so that the surface is uniform in appearance and free from rough and porous spots, irregularities and depressions. If directed by the Engineer, concrete adjacent to a longitudinal joint shall be edged.
- (h) Curing and Protection. In addition to Article 1020.13, when the use of the special patching mixture is required and the ambient temperature is between 15 °C 30 °C (55 °F.- 80 °F.), it may be necessary to cover the patch with polyethylene and insulation (R12 minimum) and maintain cover and insulation until opening strength is reached. Insulation shall not be placed when the ambient temperature at placement is greater than 32 °C (90 °F.).

When patching two or more lane widths of continuously reinforced concrete pavement in one operation and extreme daily temperature cycles are anticipated, the Engineer may require that 60 m (200 ft.) of pavement on each end of the patch be covered with wet straw and burlap or an approved insulation blanket, and that the patch be cured with wet burlap and covered in a similar manner. When covering is required, it shall be in place during the curing period. If wet straw and burlap is used, it shall be maintained in a wet condition throughout the curing period. When covering is required by the Engineer, it shall be paid for according to Article 109.04.

- (i) Shoulder Replacement. After the forms are removed but prior to opening to traffic, the disturbed shoulder area shall be replaced with like material, compacted and restored to the existing line and grade.
- (j) Joint Sealing.
  - (1) In Class A patches, all centerline joints, longitudinal joints adjacent to pcc shoulders shall be sealed according to Article 420.14(a).
  - (2) In Class B patches, all transverse joints, centerline joints, longitudinal joints adjacent to pcc shoulders, and saw-cut extensions in the shoulders shall be sealed according to Article 420.14(a) and manufacturer's recommendations. The sealant reservoir at patch boundaries shall be formed in the fresh concrete or sawed to the dimensions shown on the plans. If the reservoir is to be sawed, sawing shall not be performed until after the required curing period. The faces of the reservoir shall be thoroughly cleaned by sandblasting

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and then blown clean with compressed air having a pressure of at least 620 kPa (90 psi) and a volume of 4 m<sup>3</sup> per min. (150 cfm) of air at the nozzle. The backer rod shall be uniformly placed at the depth shown on the plans or as directed by the Engineer.

The sealing shall be done in one pour to fill the transverse joint and the centerline joint. Reheated or overheated material shall not be used.

At the Contractor's option, the centerline joint may be sawed/formed and sealed in a manner similar to the transverse joint.

- (3) In Class C patches, transverse contraction joints shall be sealed according to Article 420.14(a).
- (4) Sealing of joints as specified in (1), (2), and (3) will not be required when patching is being performed to prepare the existing pavement for bituminous resurfacing.
- **442.07 Expansion Joints.** Where expansion joints exist in the portion of the pavement that is to remain in place, the adjacent new pavement shall be constructed when possible with a similar type joint. Where existing joints are obsolete or unobtainable, the expansion joint material may be any preformed expansion joint filler meeting the requirements of Section 1051.

In Class B patches, expansion joints shall be constructed as shown on the plans. The expansion joint materials shall conform to Article 1051.08 or 1051.09, and the joints shall be sealed as specified in Article 420.14(a).

- **442.08 Opening Patches to Traffic.** The patches shall be opened to traffic according to Article 701.05(e).
- **442.09 Class D Patching.** Class D patching shall conform to the standard details and cross sections shown on the plans. The materials and the methods of performing the work shall conform to Section 406 with the following exceptions:
  - (a) Barricading Patches. Patches placed on roadways where the Traffic Control Plan permits an overnight lane closure, may remain closed until the following workday. On contracts on which overnight lane closure is not provided in the Traffic Control Plan, the removal and replacement of pavement shall be controlled by the Contractor so that all holes are filled and the compacted bituminous mixtures are cooled sufficiently to permit all barricades to be removed before dusk each day. The Contractor shall have the option of either stopping the patching early enough in the workday to permit the bituminous mixture to cool or use ice or water to induce early cooling.

Patches opened to traffic that are constructed high or become rough by rutting, shoving, or heaving shall be corrected within 48 hours by trimming off high areas and/or filling depressions. Filled areas shall be rerolled to obtain the required density.

Continued opening of the roadway before the bituminous mixture has cooled sufficiently to prevent rutting or shoving will be reason for the

Engineer to establish a shut-off time when all patch holes must be filled. No additional compensation will be allowed the Contractor if it is necessary for the Engineer to restrict the shut-off time.

- (b) Pavement Removal. This work shall conform to Article 442.05(c).
- (c) Filling Holes. Each properly prepared hole shall be filled with at least two layers of bituminous concrete mixture conforming to the requirements of Section 406 for bituminous concrete binder course. The bituminous concrete mixture shall be placed only when the temperature in the shade is at least 5 °C (40 °F.) and the forecast is for rising temperature and when the subgrade is not frozen. Each layer shall be compacted with a mechanical tamper, a vibrating tamper, or a self-propelled roller. Trucks may be used to supplement the tampers or roller. If the required density is not obtained, the Contractor shall increase the number of layers and/or compactive efforts.

The top layer shall be not less than 50 mm (2 inches) compacted thickness. At the option of the Contractor, the 50 mm (2 inch) top layer may be constructed using bituminous concrete surface course. To facilitate possible extra compaction and consolidation by traffic, the surface of the completed patch may be finished up to 13 mm (1/2 inch) above the existing payement.

- (d) Density. After final compaction, the finished patch shall have a density of not less than 93 percent of the theoretical density of the mixture. The density of the bituminous mixture placed in patches shall be measured by nuclear test methods or obtained from specimens furnished by the Contractor according to the requirements of Article 406.16(b) except as hereinafter specified.
  - (1) Coring. The diameter of a core specimen shall in no case be less than 90 mm (3 5/8 inches). Two specimens shall be taken from each type of patch placed during a day and these shall be furnished not later than the morning of the first work day following placement of the patches. When directed by the Engineer, additional specimens shall be taken but the total number per day from each type of patch shall not exceed 10. The Contractor shall remove the specimens at locations designated by the Engineer and transport them to the plant laboratory. Care shall be exercised to avoid damage to the specimens. The holes caused by the removal of the specimens shall be refilled immediately with a bituminous material meeting these Specifications, compacted and finished to the satisfaction of the Engineer. The cost of this work will not be paid for separately, but shall be included in the unit prices bid for the item(s) of patching involved.
- (e) Additional Compaction. Traffic shall be permitted on the patches for at least 3 days prior to resurfacing.
- (f) Maintenance of Patch. The surface of the completed patch shall be maintained in a smooth condition. High spots shall be trimmed level with the pavement surface. If depressions develop, they shall be filled with a Surface Course or a B Binder Mixture compacted with a tandem or three-wheel roller. No additional compensation will be permitted for

maintaining smooth patches.

If the patched pavement is to be resurfaced on the same contract, minor depressions in the patch surface may be filled and compacted as a part of the resurfacing operation.

**442.10 Method of Measurement.** Pavement removal and replacement of the various classes and types will be measured for payment in place, and the area computed in square meters (square yards).



To the extend possible, the contract documents contain information on the thickness of the existing pavement including subsequent resurfacing(s). In the event the average combined thickness of the existing pavement and overlays in an area to be patched differs from the thickness shown on the plans, the Engineer will adjust the patching quantity, for the specific patch type, of the individual paths meeting this requirement as indicated by the following chart. The quantities will be increased when the thickness is greater and decreased when the thickness is less.

% change of thickness	% change of quantity
0 to less than 15	0
15 to less than 20	10
20 to less than 30	15
30 and greater	20

No other compensation will be allowed for variations in patching thickness from that shown on the plans.

If additional pavement, subbase, or subgrade material is removed due to negligence on the part of the Contractor, the additional quantity of pavement removal and replacement or subgrade material will not be measured for payment. Shoulder removal and replacement resulting from edge forming will not be measured for payment.

When expansion joints are to be included in Class B patches, as shown on the plans or as directed by the Engineer, the expansion joint will be measured for payment in place in meters (feet).



**442.11** Basis of Payment. Where the Contractor has the option of using either Class C or Class D patches, this work will be paid for at the contract unit price per square meter (square yard) for PAVEMENT PATCHING, of the type and thickness specified.



Where the Department requires a specific class of patch be used, this work will be paid for at the contract unit price per square meter (square yard) for CLASS A PATCHES, CLASS B PATCHES, CLASS B PATCHES (HINGE JOINTED), CLASS C PATCHES, OR CLASS D PATCHES of the type and thickness specified.



When expansion joints are included in Class B patches, the expansion joint will be paid for at the contract unit price per meter (foot) for CLASS B PATCH - EXPANSION JOINT.

Where unsuitable material is encountered in the subgrade or subbase and its removal and replacement is required by the Engineer, such removal and replacement shall be performed by the Contractor and will be paid for according to Article 109.04.



When additional pavement removal due to unsound concrete is directed by the Engineer, the additional saw-cuts required will be paid for according to Article 109.04. The additional quantity of pavement removal and replacement will be paid for at the contract unit price for the item(s) of patching involved.

The above prices shall include the cost of performing the work as specified herein, including sawing and removal and disposal of existing materials; furnishing and installing contraction joints, pavement reinforcement, dowel bars, tie bars, expansion anchor ties and contraction joints, as required; and shoulder replacement and joint sealing.

## SECTION 443. REFLECTIVE CRACK CONTROL TREATMENT

- **443.01 Description.** This work shall consist of constructing reflective crack control treatments of the type specified. Area reflective crack control treatment shall be either System A or C at the option of the Contractor. Strip reflective crack control treatment shall be either System A, B or C at the option of the Contractor.
- **443.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 Materials:

	Item	Article/Section
(a)	Reflective Crack Control System	

**443.03 Equipment.** Equipment shall meet the requirements of the following Articles of Section 1100 - Equipment:

	Item /	Article/Section
(a)	Pressure Distributor	1102.05
(b)	Mechanical Sweeper (Note 1)	1101.03
(c)	Asphalt-Rubber Equipment (Note 2)	
(d)	Cover Aggregate Spreader (Note 3)	
(e)	Rolling Equipment (Note 4)	1101.01
(f)	Mechanical Laydown Equipment (Note 5)	

- Note 1. For pavement cleaning and excess cover aggregate removal.
- Note 2. All equipment utilized in processing and application of the asphalt-rubber material shall be a truck or trailer mounted self-powered distributor equipped with a heating unit, a mixing unit capable of producing a homogenous mixture of asphalt and rubber, pump(s) capable of spraying asphalt-rubber within  $\pm 0.22$  L/m<sup>2</sup> ( $\pm 0.05$  gal. per sq. yd.) of the specified rate, and a fully circulating spray bar capable of applying asphalt-rubber without a streaked or otherwise irregular pattern.

The distributor shall include a tachometer, pressure gages, volume measuring devices, an onboard weighing device to aid in proportioning materials and a thermometer. A "bootman" shall accompany the distributor and ride in a position so that all spray bar nozzles are in his/her full view and readily accessible for unplugging.

Note 3. The cover aggregate (chip) spreader shall be a self-propelled

machine with an aggregate receiving hopper in the rear, belt conveyors to carry the aggregate to the front, and a spreading hopper equipped with full-width distribution auger and spread rolls. The spreader shall be in good mechanical condition and be capable of applying the cover material uniformly across the spread at the specified rate.

Note 4. Used for the required rolling of the cover material.

Note 5. Equipment shall be capable of handling full rolls of fabric, and shall be capable of laying the fabric smoothly without excessive wrinkles and/or folds.

Stiff brush brooms to smooth the fabric and scissors to cut the fabric shall be provided.

#### CONSTRUCTION REQUIREMENTS

- **443.04 Surface Preparation.** The surface on which reflective crack control system is to be constructed shall be clean and dry. All base failures shall be repaired and all cracks, spalls, potholes or other depressions shall be sealed with an approved crack sealer or filled with mixture for cracks, joints and flangeways according to Article 406.06 and to the satisfaction of the Engineer before any crack control system is constructed. When, in the opinion of the Engineer, the existing pavement surface cannot be rendered sufficiently smooth, by crack sealing and patching, to receive the reflective crack control systems specified, a leveling binder shall be placed prior to construction of the reflective crack control system. The leveling binder shall be constructed according to Section 406.
- **443.05 Placing and Compaction of Bituminous Mixtures.** Bituminous leveling binder, binder course or surface course mixtures placed on top of any reflective crack control system shall be placed at a maximum temperature of 150 °C (300 °F.). All other preparation, transportation, placing and compaction of bituminous mixtures shall be done in conformance with Section 406.
- **443.06 Reflective Crack Control System A.** The area to be covered with fabric shall be sprayed uniformly with asphalt binder at a rate of 1 to 1.3 L/m² (0.25 to 0.30 gal. per sq. yd.) as directed by the Engineer. Binder application shall be accomplished with a pressure distributor for all surfaces except, where the distributor does not have room to operate, hand spraying will be allowed. The width of the spray application shall be no more than 150 mm (6 inches) wider than the fabric and no less than the fabric width plus 50 mm (2 inches). The binder shall not be applied at a temperature greater than 160 °C (325 °F.) to avoid damage to the fabric. After the binder has been sprayed, the fabric shall be unrolled or hand placed onto the binder without delay. Every effort must be made to lay the fabric as smoothly as possible to avoid wrinkles. Wrinkles large enough to cause laps of the fabric shall be cut and laid out flat. The fabric shall be broomed or squeegeed to remove air bubbles and make complete contact with the road surface.

The fabric shall overlap the adjacent fabric panel a minimum of 50 mm (2 inches). Additional asphalt binder shall be applied by hand to make the joints where overlap is greater than 50 mm (2 inches). The transverse joints shall be made in such a manner to avoid pickup by the paver. The direction of paving shall be in the direction of fabric placement.

When placed as a strip treatment, the strip shall be 600 mm (24 inches) wide.

**443.07 Reflective Crack Control System B.** The primer to be used with the waterproofing membrane shall be supplied by the manufacturer of the membrane and shall be compatible with the membrane.

The waterproofing membrane interlayer shall be placed as shown on the plans. Placement of the membrane shall be done only when the temperature is above 5 °C (40 °F.) and the pavement surfaces are dry and free of dirt and debris.

The surface shall be primed according to the manufacturer's recommendations prior to placement of the membrane. The primer shall be placed on the concrete surface at a minimum rate of 7 m $^2$ /L (300 sq. ft. per gal.), shall extend 25 mm (1 inch) wider than the membrane, and shall be allowed to dry until tackfree before applying the membrane. Primer shall be placed on both portland cement concrete and asphaltic concrete pavement surfaces.

Any spall greater than 75 mm (3 inches) in diameter which will cause a failure of the material to bond to the pavement or will leave a cavity under the material shall be corrected prior to the placement of the waterproofing membrane interlayer.

The membrane shall be installed in nominal 300-mm (12-inch) widths [ 290 mm (11-3/8 inches) minimum] and shall be centered over the joint or crack within a 25 mm (1 inch) tolerance. Laps will be permitted in the membrane with a minimum overlap of 65 mm (2 1/2 inches). The membrane shall be installed straight and wrinkle-free with no curled or uplifted edges. Any wrinkles over 10 mm (3/8 inch) width shall be slit and folded down.

All membrane shall be surface dry before placement of the bituminous concrete overlay. Paving may begin immediately after membrane placement.

**443.08 Reflective Crack Control System C.** Immediately prior to application of a tack coat, the surface shall be thoroughly cleaned by sweeping.

When placed as a strip treatment, the strip shall be 600 mm (24 inches) wide. Also when placed as a strip treatment, a self-propelled distributor will not be required for applying the tack coat nor the asphalt-rubber, nor will a self-propelled spreader be required to place the cover aggregate. Equipment which meets the approval of the Engineer and applies a uniform application of tack coat, asphalt rubber and cover aggregate may be used.

- (a) Tack Coat. A tack coat of diluted emulsified asphalt, of the type and grade specified in Article 1062.03, shall be applied to the cleaned surface and allowed to fully cure before spreading of the asphalt rubber material. The emulsified asphalt shall be diluted 1 part water to 1 part emulsified asphalt by volume with from 0.4 to 0.6 L/m<sup>2</sup> (0.10 to 0.15 gal. per sq. yd.) of the diluted material applied.
- (b) Asphalt-Rubber Mixture. For the asphalt-rubber mixture, the Contractor has the choice of using either a vulcanized rubber in asphalt with a diluent (Mixture 1) or a crumb rubber blend in asphalt which has been treated with an extender oil (Mixture 2).
  - (1) Mixture 1. The percentage of vulcanized rubber shall be 33  $\pm$  4 percent by mass (weight) of the asphalt cement in Mixture 1.

The temperature of the asphalt shall be between 175 °C (350 °F.) and 200 °C (395 °F.) before addition of the vulcanized rubber. The material shall be carefully combined and mixed and reacted for a period of time as required by the Engineer which shall be based on laboratory testing by the asphalt-rubber supplier or contracting agency.

The temperature of the asphalt-rubber mixture shall be above 160 °C (325 °F.) during the reaction period.

After the reaction between asphalt and rubber has occurred, the viscosity of the hot asphalt-rubber mixture may be adjusted for spraying and/or better "wetting" of the cover material by the addition of a diluent. The diluent shall not exceed 7 1/2 percent by volume of the hot asphalt-rubber mixture.

If a job delay results after the full reaction has occurred, the material may be allowed to cool and be slowly reheated to an acceptable spraying temperature just prior to application. However, because of the polymer reversion that can occur when crumb rubber is held for prolonged high temperatures, the material shall not be reheated to temperatures above 160 °C (325 °F.). Additional diluent up to a maximum of 3 percent by volume of the hot asphalt-rubber mixture may be used after reheating of the material.

- The percentage of crumb rubber blend shall be Mixture 2.  $25 \pm 4$  percent by weight of the asphalt cement. Prior to adding the crumb rubber blend, the asphalt and extender oil shall be mixed in such quantities to produce an absolute viscosity of 6 Pa·s (600 poises) at 60 °C (140 °F.) when tested according to the requirements of AASHTO T 202. The asphalt oil blend shall first be heated to 200 °C (400 °F.) minimum and be thoroughly mixed before beginning incorporation of the crumb rubber blend. The crumb rubber blend shall be added as quickly as possible and the mix shall be given adequate circulation and agitation during the addition-mixing process to provide for proper dispersion. As soon as the mixing of the rubber is complete, Mixture 2 may be applied to the roadway. However, if the material is not to be used within one hour of mixing, the temperature shall be reduced to below 160 °C (325 °F.) and reheated on the project site.
- (c) Application of Asphalt-Rubber Material. Placement of the asphalt-rubber shall be made only under the following conditions:
  - (1) The pavement surface temperature is not less than 15 °C (60 °F.) and rain is not imminent.
  - (2) The pavement surface is clean and dry.
  - (3) The wind conditions are such that excessive blowing of the spray bar fans is not occurring, and
  - (4) All construction equipment such as asphalt-rubber distributor, aggregate spreader, haul trucks with cover aggregate, and rollers are in position and ready to commence placement operations.

The asphalt-rubber mixture shall be applied at a temperature of

- 140 °C 160 °C (290 °F. 325 °F.) at a rate of  $2.5\pm0.2$  L/m² ( $0.6\pm0.05$  gal. per sq. yd.) [based on 0.9 kg per hot L (7 1/2 lbs. per hot gal.)]. Transverse joints shall be constructed by placing building paper across and over the end of the previous asphalt-rubber application. Once the spraying has progressed beyond the paper, the paper shall be removed immediately and disposed of as directed by the Engineer. All longitudinal joints shall be lapped a minimum of 100 mm (4 inches).
- (d) Application of Cover Material. Cover material shall be applied immediately to the asphalt-rubber after spreading at a rate of 16 to 22 kg/m² (30 to 40 lbs. per sq. yd.). If steel slag is used for cover material, the spread quantity shall be increased in proportion to its higher specific gravity.
  - At the time of application to the asphalt-rubber, cover aggregate shall not contain any free moisture.
- (e) Rolling. At least 3 pneumatic-tired rollers shall be provided to accomplish the required embedment of the cover material. At some project locations or where production rates indicate, fewer rollers may be utilized as directed by the Engineer.
  - Sufficient rollers shall be used for the initial rolling to cover the width of the aggregate spread with one pass. The first pass shall be made immediately behind the aggregate spreader, and if the spreading is stopped for any reason, the spreader shall be moved ahead or off to the side so that all cover material may be immediately rolled. Four complete coverages with rollers shall be made with all rolling completed within 2 hours after the application of the cover material.
- (f) Opening the Completed Asphalt-Rubber Membrane Interlayer to Traffic. Except when it is necessary that hauling equipment must be on the newly applied membrane, traffic of all types shall be kept off the membrane until it has had time to set properly. The speed of all hauling equipment shall not exceed 25 km/h (15 mph) when traveling over a membrane which is not adequately set. The minimum traffic free period shall be not less than 2 hours.
- (g) Removing Loose Cover Aggregate. The sweeping shall be sufficient following placement of the membrane to remove all loose aggregate without dislodging any embedded aggregate.
- (h) Placement of Asphalt Concrete. The placement of the asphalt concrete overlay shall be delayed as directed by the Engineer for sufficient time to allow for adequate evaporation of the diluent or extender oil. A minimum of 2 hours shall elapse.
- **443.09 Method of Measurement.** Area Reflective Crack Control Treatment will be measured for payment in place and the area computed in square meters (square yards). Strip Reflective Crack Control Treatment will be measured for payment in meters (feet) along the joint or crack parallel to the centerline of the pavement.
- **443.10** Basis of Payment. This work will be paid for at the contract unit price per square meter (square yard) for AREA REFLECTIVE CRACK CONTROL

TREATMENT or per meter (foot) for STRIP REFLECTIVE CRACK CONTROL TREATMENT which prices shall be payment for completing all work.

## SECTION 444. FIBERGLASS FABRIC REPAIR SYSTEM

- **444.01 Description.** This work shall consist of installation of a Fiberglass Fabric Repair System prior to placement of an asphalt overlay.
  - 444.02 Materials. Materials shall conform to the requirements of Article 1063.
- **444.03 Equipment.** Equipment shall consist of suitable sweepers, air compressors, hand brooms, pouring buckets, rubber-edged squeegees, cutting knives, and melting kettles. All hand tools shall be in a clean condition. Melting kettles shall be propane heated, with temperature controlling thermostat. Oil or kerosene fired, single jacketed kettles will not be allowed. The melting kettle shall be clean and free from other bituminous materials which might change the properties of the specified Bituminous Adhesive. Since the adhesive is melted and used at higher temperatures than ordinary bituminous paving material, safety procedures concerning fire hazards and skin burns shall be observed.

# **CONSTRUCTION REQUIREMENTS**

**444.04 General.** The existing pavement on which the Repair System is to be placed as marked by the Engineer shall be dry and free of dirt, rocks and other debris. All base failures shall be repaired and all cracks, spalls, potholes or other depressions shall be sealed with an approved crack sealer or primed and filled with Leveling Binder - Hand Method according to the applicable portions of Section 406 and to the satisfaction of the Engineer before the Repair System is constructed.

The Repair System shall be installed on a clean pavement. Cleaning shall be accomplished by suitable sweepers, compressed air or hand brooms. The specified Bituminous Adhesive, heated to 190 °C  $\pm$  15 °C (375 °F.  $\pm$  25 °F.), shall be applied by means of a hand spray bar or a pouring bucket and squeegee. The adhesive shall be squeegeed with sufficient uniformity to prevent streaking or ridging and shall extend a minimum of 25 mm (1 inch) beyond all edges of the fiberglass fabric. Following application of the adhesive on the pavement surface, the reinforcement fabric shall immediately be placed over it. If it is necessary to use 2 or more pieces of fabric to obtain the required width or length, the material shall be overlapped by a minimum of 50 mm (2 inches). Wrinkles in the fabric strips will not be permitted. Additional adhesive shall be squeegeed on top of the fabric and shall extend a minimum of 25 mm (1 inch) beyond all its edges. The application rate for 2 coats of Bituminous Adhesive in the system shall be a minimum of 3 L/m² (0.70 gal. per sq. yd.). When proper thickness is achieved, the weave pattern of reinforcement fabric shall be detectable through the top coat of the adhesive.

The Repair System shall be applied only when the ambient and pavement temperatures are at least 10  $^{\circ}$ C (50  $^{\circ}$ F.) and rising. No materials shall be applied while the pavement surface is wet. The pavement surface shall be thoroughly dry before work begins.

The Repair System may be opened to construction traffic after a 30 minute minimum set time. The Contractor shall be responsible for the replacement of any damaged fabric at his expense prior to overlaying.

- **444.05 Method of Measurement.** The Fiberglass Fabric Repair System will be measured for payment in place and the area computed in square meters (square yards) of fabric surface. No payments will be allowed for the fabric overlaps or the minimum extension of bituminous material beyond the edges of the fabric.
- **444.06 Basis of Payment.** This work will be paid for at the contract unit price per square meter (square yard) for FIBER GLASS FABRIC REPAIR SYSTEM, which price shall include preparation of existing pavement and other incidentals necessary to place the system, except that Leveling Binder (Hand Method) will be paid for separately at the contract unit price per metric ton (ton) for LEVELING BINDER (HAND METHOD), as specified in Article 406.24.

## SECTION 445. OPEN-GRADED ASPHALT FRICTION COURSE

- **445.01 Description.** This work shall consist of the construction of an Open-Graded Asphalt Friction Course (OGAFC) on a new bituminous concrete binder course.
- **445.02 Materials.** Materials shall meet the following requirements of Section 1000 Materials:

	Item	Article/Section
(a)	Coarse Aggregate (Note 1)	1004.03
(b)	Fine Aggregate	1003.03
(c)	Mineral Filler	1011
(d)	Bituminous Material (Note 2)	1009

Note 1. Coarse Aggregate. Any of the following coarse aggregates may be used to produce OGAFC mixtures.

- (1) Description.
  - a. Crushed Steel Slag. Crushed steel slag shall be the graded product resulting from the processing of steel slag from an open-hearth or basic-oxygen furnace.
  - b. Crushed Slag.
  - c. Crushed Trap Rock.
  - d. Crushed Sandstone.
- (2) Quality. The aggregate shall have Class B quality or better meeting the requirements of Article 1004.01(b), except the Los Angeles Abrasion Test, AASHTO T 96, does not apply to crushed slag aggregate.
- (3) Gradation. The coarse aggregates shall be uniformly graded from coarse to fine and when tested by means of laboratory sieves (square openings) shall conform to the following gradation. A maximum of 20 percent fine aggregate may be blended with the coarse aggregate to obtain the required gradation.

## Open-Graded Asphalt Friction Course

Passing 12.5 mm (1/2 inch) sieve	100%
Passing 9.5 mm (3/8 inch) sieve	90-100%
Passing 4.75 mm (No. 4) sieve	30-50%
Passing 2.36 mm (No. 8) sieve	10-18%
Passing 75 μm (No. 200) sieve	2-5%

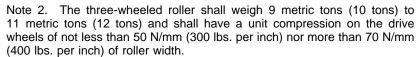
Note 2. Asphalt cement grade AC-10 or AC-20 shall be used. The grade to be used will be as shown on the plans. The Contractor shall use an approved heat-stable anti-stripping additive. The anti-stripping additive shall meet the approval of the Engineer based on the results of laboratory tests conducted by the Bureau of Materials and Physical Research. The additive shall be added to the asphalt tank at the recommended dosage [ 0.5 to 1.0 percent by mass (weight) of asphalt cement] and thoroughly mixed by circulation of the asphalt for at least 4 hours prior to being incorporated into the mix. The exact amount of additive will be determined by the Engineer based on laboratory tests.

# **445.03 Equipment.** Equipment shall meet the requirements of the following Articles of Section 1100 - Equipment:

	Item	Article/Section
(a)	Self-propelled Pneumatic-Tired Roller (Note 1)	1101.01
(b)	Three-Wheel Roller (Note 2)	1101.01
(c)	Tandem Roller (Note 3)	1101.01
(d)	Hot-Mix Plant (Note 4)	1102.01
(e)	Spreading and Finishing Machine (Note 5)	1102.03
(f)	Pressure Distributor	1102.05
(g)	Heating Equipment	1102.07
	Trench Roller	
(i)	Vibratory Roller	1101.01

Note 1. The self-propelled pneumatic-tired roller shall develop a compression of not less than 50 N/mm (300 lbs. per inch) nor more than 90 N/mm (500 lbs. per inch) of width of the tire tread in contact with the bituminous surface. The tires shall be inflated to an air pressure of not less than 550 kPa (80 psi).





- Note 3. The tandem roller shall weigh 7 metric tons (8 tons) to 11 metric tons (12 tons) and shall have a unit compression on the drive wheels of not less than 45 N/mm (250 lbs. per inch) to 70 N/mm (400 lbs. per inch) of roller width.
- Note 4. The hot-mix plant shall be a batch type plant.
- Note 5. The spreading and finishing machine shall be equipped with either a mechanical leveling device or an automatic electronic grade as specified in Article 1102.03.

### CONSTRUCTION REQUIREMENTS

- **445.04 General.** Article 406.04 shall apply except the mixture shall be placed only when the daily high air temperature is at least 15 °C (60 °F.) 2 days prior to placement and there is a forecast of high temperature of at least 15 °C (60 °F.) during and for 2 days after construction. Official National Weather Service data for the construction area shall be used.
  - **445.05 Keeping Road Open to Traffic.** Article 701.05(c)(3) shall apply.
- **445.06** Preparation, Priming and Leveling of Existing Bituminous Concrete Surfaces. Prior to placing OGAFC directly over an existing bituminous concrete surface, the existing surface shall be leveled. The preparation, priming and leveling of the existing surface shall be accomplished, measured and paid for according to the applicable portions of Section 406.
- 445.07 Preparation of Mineral Aggregates, Asphalt Cement and Bituminous Mixtures. Preparation of asphalt cement shall be according to Article 406.08. Preparation of mineral aggregates be according to Article 406.09 except the aggregates shall be heated in such a manner as to assure that the mixing temperature is uniformly maintained. The aggregates shall be dried to less than 0.5 percent residual moisture by weight, as determined by hot bin samples. This may require the aggregate to be processed twice through the drier. The aggregate(s) shall be screened into at least 2 sizes before mixing.

Preparation of bituminous mixtures shall conform to Article 406.12 except the mixing temperature shall not exceed 125 °C (260 °F.).

**445.08 Mixing Formula.** At least 2 weeks prior to the placement of any of these mixtures, the Contractor shall furnish to the Engineer samples of the aggregates he proposes to use. The Engineer shall perform mix design tests to determine the exact proportions for the mix which will be between the following composition limits by weight:

Aggregate	85-95%
Asphalt Cement (Note 1)	. 5-15%

- Note 1. The range of asphalt content is based on the varying physical properties of the coarse aggregate that can be used for the manufacture of OGAFC. Upon request, the Engineer will provide the Contractor with an approximate asphalt content,  $\pm$  1%, for any given coarse aggregate. The amount of anti-stripping agent will not be included in this percentage.
- **445.09 Transportation.** These mixtures shall be transported in covered and insulated trucks conforming to Article 406.14. The cover shall be rolled back before the load is dumped into the finishing machine. Covering may be waived on short hauls or in hot weather.
  - **445.10 Placing.** Article 406.15 shall apply except for the following:
  - (a) The mixture shall be at a temperature of 110 °C  $\pm$  10 °C (230 °F.  $\pm$  20 °F.) at the time of placement.
  - (b) The mix shall be placed within one hour from the time of completion of

mixing.

- (c) No straightedging will be required.
- (d) The paver speed shall be limited to not more than 10 m/min. (35 ft. per min.).
- (e) The mix shall be placed only at a uniform nominal thickness of 15 mm (5/8 inch) compacted.

Note: Approximate unit weights for Open-Graded Asphalt Friction Course mixtures are:

- (1) Crushed Steel Slag 40 kg/m<sup>2</sup> (75 lbs./sq. yd.) at 15-mm (5/8-inch) thickness.
- (2) Crushed Slag 30 kg/m<sup>2</sup> (56 lbs./sq. yd.) at 15-mm (5/8-inch) thickness.
- (3) Crushed Trap Rock 35 kg/m<sup>2</sup> (66 lbs./sq. yd.) at 15-mm (5/8-inch) thickness.
- **445.11 Compaction.** Immediately after placement of the mixtures, the pavement shall be compacted by 2 tandem rollers. No more than a total of 3 coverages by the rollers will be required. When approved by the Engineer, vibratory rollers may be used in the static mode. More than 3 coverages may be required when using vibratory rollers due to lower unit weights. The Engineer may eliminate one roller on small jobs. The amount of rolling shall be confined to only that necessary for consolidating the bituminous mixture and bonding it to the underlying surface. Excessive rolling shall be avoided.
- **445.12 Protection.** No traffic shall be allowed on any portion of the completed pavement until after the final rolling and the mixture has cooled adequately to prevent pickup.
- **445.13 Method of Measurement.** Open-Graded Asphalt Friction Surface Course will be measured for payment in place and the area computed in square meters (square yards). The width used shall be that which is shown on the plans.
- **445.14 Basis of Payment.** This work will be paid for at the contract unit price per square meter (square yard) for OPEN-GRADED ASPHALT FRICTION SURFACE COURSE.

# SECTION 446. PAVEMENT REHABILITATION BY THE HEAT-SCARIFY-OVERLAY METHOD

**446.01 Description.** This work shall consist of rehabilitating an asphalt pavement by heating, scarifying, reshaping and rejuvenating the surface with the addition of a new bituminous concrete surface according to the thickness specified on the plans.

### **CONSTRUCTION REQUIREMENTS**

**446.02 General.** The entire surface to be rehabilitated shall be free of water, earth and foreign material. All base failures shall be repaired prior to the heating-scarifying process according to Section 358. Rehabilitation work shall be performed only when the air temperature in the shade is at least 7 °C (45 °F.) and the forecast is for rising temperatures.

The surface of the existing pavement shall be heated with a continuously moving heater to allow the pavement to be scarified to a 20-mm (3/4-inch) average depth with the surface temperature of the old pavement not to exceed 190 °C (375 °F.). Scarification of 20 mm (3/4 inch) will yield an approximate weight of 45 kg/m² (9 lbs. per sq. ft.) of loose material. Heat shall be applied under an enclosed or shielded hood and shall extend at least 100 mm (4 inches) beyond the width of scarification on both sides. Scarifying shall be accomplished with pressure scarifiers. The scarifying unit shall be equipped to scarify and move material away from the gutter flags for a depth of 15 mm (1/2 inch) by 100 mm (4 inches) wide. The heating-scarifying operation shall not exceed 10 m (30 ft.) per minute. When a repaving pass is being made adjacent to a previously placed mat, the longitudinal repaving seam shall extend at least 50 mm (2 inches) into the previously placed mat.

Immediately after the scarifying operation, an asphalt modifier approved by the Bureau of Materials and Physical Research shall be applied at the rate of 0.5 L/m² (0.10 gal. per sq. yd.). The Engineer may waive or adjust the requirement for the asphalt modifier if the existing pavement condition warrants this action. The surface shall then be leveled by distributing the heated, scarified and treated (HST) material over the width being processed so as to produce a uniform cross section. The minimum temperature of the HST material after leveling shall be 80 °C (175 °F.). If the new bituminous mixture is to be placed later as a separate operation, the HST material shall be compacted before the temperature of the mix drops below 65 °C (150 °F.). Compaction shall be accomplished with a self-propelled pneumatic-tired roller meeting the requirements of Articles 1101.01(c) and 406.16(a).

Within 48 hours of the HST operation, a uniform layer of not less than 40 kg/m² (70 lbs. per sq. yd.) of bituminous surface course mixture meeting the requirements of Section 406 for Class I, Type 3, shall be placed with a spreading and finishing machine meeting the requirements of Article 1102.03. Whenever the layer is between 40 kg/m² (70 lbs. per sq. yd.) and 75 kg/m² (140 lbs. per sq. yd.), CA 16 gradation will be required. The spreading and finishing machine shall be capable of spreading and finishing the surface in lane widths to the specified cross section and thickness. The activated screed or strikeoff assembly shall effectively produce a finished surface of the required uniform slope and texture without tearing, shoving or gouging the mix. The screed shall be adjustable to taper the finished surface to the height of the gutter flag. The surface shall be compacted thoroughly and uniformly with a pneumatic-tired roller followed by a tandem finish roller meeting the requirements of Articles 1101.01(c), 1101.01(e) and 406.16(a). The forward speed of the spreading and finishing machine shall insure, as near as possible, a continuous operation but shall not exceed 10 m (35 ft.) per minute.

#### 446.03 Method of Measurement.

(a) Contract Quantities. The requirement for use of contract quantities shall

be according to Article 202.07(a).

- (b) Measured Quantities. The heat-scarifying process will be measured for payment in place and the area computed in square meters (square yards). The asphalt modifier will be measured for payment in liters (gallons) according to Article 1009.03. The hot bituminous surface mixture will be measured for payment in metric tons (tons) according to Article 406.23.
- **446.04 Basis of Payment.** This work will be paid for at the contract unit price per square meter (square yard) for HEAT-SCARIFYING, per metric ton (ton) for HOT BITUMINOUS SURFACE MIXTURE and per liter (gallon) for ASPHALT MODIFIER.

If provided as a pay item, the preparation of the base will be paid for according to Article 358.07. If not provided as a pay item, preparation of the base, including additional material required, shall be considered as included in the contract unit price bid for Heater-Scarifying, and no additional compensation will be allowed.

### SECTION 447. SINGLE PASS ASPHALT REPAVING

**447.01 Description.** This work shall consist of repaving the existing asphalt pavement in a continuous multi-step process of heating, scarifying and rejuvenating the old asphalt surface with the addition of a new asphalt mixture to form a bituminous concrete surface of the required thickness as specified on the plans.

## **CONSTRUCTION REQUIREMENTS**

**447.02 General.** The entire surface to be repaved shall be cleaned of water, earth and foreign material. All base failures shall be repaired prior to the repaving process according to Section 358. Asphalt repaving shall be performed only when the air temperature in the shade is at least 7 °C (45 °F.) and the forecast is for rising temperatures.

The surface of the existing pavement shall be heated with a continuously moving heater to allow the pavement to be scarified to a 20 mm (3/4 inch) average depth with the surface temperature of the old pavement not to exceed 190 °C (375 °F.). Scarification of 20 mm (3/4 inch) will yield an approximate weight of 45 kg/m² (9 lbs. per sq. ft.) of loose material. Heat shall be applied under an enclosed or shielded hood. When abutting a bituminous concrete mat, the heating operation shall extend at least 100 mm (4 inches) beyond the width of scarification on both sides.

Scarifying shall be accomplished with pressure loaded scarifiers. The scarifying unit shall be so equipped to scarify and move material away from the gutter flags for a depth of 15 mm (1/2 inch) by 100 mm (4 inches) wide. When a repaving pass is being made adjacent to a previously placed mat, the longitudinal repaving seam shall extend at least 50 mm (2 inches) into the previously placed mat.

After the scarifying operation and prior to mixing, an asphalt modifier approved by the Bureau of Materials and Physical Research shall be applied at the rate of 0.5 L/m<sup>2</sup> (0.10 gal. per sq. yd.). The engineer may waive or adjust the requirement for the asphalt modifier if the existing pavement condition warrants this action.

The heated-scarified mix with modifier shall then be processed by one of the following methods:

- (a) After the addition of the modifier, the heated-scarified material shall be mixed either by an auger or mixing unit and then distributed over the width of the pavement by a leveling unit to produce a uniform cross section. The leveling device shall have the capability of windrowing excess material to one side for removal when necessary. The minimum temperature of the processed mix as it leaves the leveling unit shall be 80 °C (175 °F.). The minimum depth of processed mix laid as a leveling course shall be 15 mm (1/2 inch). Immediately after reshaping the processed mix, a uniform layer of not less than 40 kg/m<sup>2</sup> (70 lbs. per sq. yd.) of new surface course mixture meeting the requirements of the applicable portions of Section 406 for Class I, Type 3, shall be applied by a vibratory screed or strike-off assembly, heated if necessary. The machine shall be capable of spreading and finishing the surface in lane widths to the specified section and thickness. The vibratory screed or strike-off assembly shall effectively produce a finished surface of the required uniform slope and texture without tearing, shoving or gouging the mix. The outside section of the screed shall be adjustable to taper the finished surface to the height of the gutter flag. The surface shall be compacted thoroughly and uniformly with a pneumatic-tired roller followed by a tandem roller meeting the requirements of Articles 1101.01(c) and 1101.01(e). The complete repaying operation shall not exceed 9 m (30 ft.) per minute.
- (b) After the addition of the modifier, the heated-scarified material shall be mixed either by auger or mixing unit. Virgin mix, meeting the applicable requirements of Section 406 of the Standard Specifications, shall be added to the mixing operation at this time at a rate of not less than 40 kg/m<sup>2</sup> (70 lbs. per sq. yd.) of finished pavement. The processed mixture shall then be distributed over the width of the pavement by a vibratory screed or strike-off assembly, heated if necessary. The machine shall be capable of spreading and finishing the surface in lane widths to the specified section and thickness. The vibratory screed or strike-off assembly shall effectively produce a finished surface of the required uniform slope and texture without tearing, shoving or gouging the mix. The outside section of the screed shall be adjustable to taper the finished surface to the height of the gutter flag. The surface shall be compacted thoroughly and uniformly with a pneumatic-tired roller followed by a tandem roller meeting the requirements of Articles 1101.01(c), 1101.01(e), and 406.16(a). The completed paving operation shall not exceed 9 m (30 ft.) per minute. The minimum temperature of the processed mixture behind the paver shall be 110 °C (225 °F.). The minimum compacted depth of processed mix laid shall be 30 mm (1-1/4 inches).
- **447.03 Method of Measurement.** The repaved surface will be measured for payment in place and the area computed in square meters (square yards). Hot bituminous surface mixture will be measured for payment in metric tons (tons) according to Article 406.23. Asphalt modifier will be measured for payment in liters (gallons) according to Article 1009.03.
- **447.04 Basis of Payment.** This work will be paid for at the contract unit price per square meter (square yard) for REPAVING, per metric ton (ton) for HOT

BITUMINOUS SURFACE MIXTURE, and per liter (gallon) for ASPHALT MODIFIER.

If provided as a payment item, the preparation of the base will be paid for as specified in Article 358.07. If not provided as a payment item, the preparation of the base shall be considered as included in the contract unit price bid for Repaving, and no additional compensation will be allowed.

## **SECTION 448. MICRO-SURFACING**

**448.01 Description.** This work shall consist of a latex modified asphalt pavement course to fill ruts and/or provide a wearing course for existing pavements.

**448.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 - Materials:

	Item	Article/Section
(a)	Aggregate (Note 1)	
(b)	Mineral Filler (Note 2)	1001
(c)	Water	1002
(d)	Latex Modified Emulsified Asphalt	

Note 1. The aggregate shall be 100% crushed material and shall be crushed limestone, crushed dolomite, crushed sandstone, crushed air-cooled blast furnace slag, or crushed gravel, Class A quality meeting the gradation limits in the Table below and the physical properties of Article 1003.01. When used as a surface course, the aggregate shall conform to the friction requirements of the Department's "Skid Accident Reduction Program".

# Gradation Limits for Aggregate

Surface Mix	Rutfill Mix	<u>X</u>
100	10	00
100	90 - 10	00
85 - 100	55 - 7	75
50 - 80	40 - 5	55
40 - 65	25 - 4	40
25 - 45	19 - 3	34
13 - 25	10 - 2	20
5 - 15	4 - 1	10
	100 100 85 - 100 50 - 80 40 - 65 25 - 45 13 - 25	100 10 100 90 - 10 85 - 100 55 - 7 50 - 80 40 - 5 40 - 65 25 - 4 25 - 45 19 - 3 13 - 25 10 - 2

Note 2. Mineral filler shall be Type 1 portland cement.

**448.03 Equipment.** Equipment shall meet the requirements of the following Articles of Section 1100 - Equipment:

	Item	Article/Section
(a)	Micro-Surfacing Mixing Machine	1102.11
(b)	Micro-Surfacing Spreader	1102.12

#### CONSTRUCTION REQUIREMENTS

**448.04 General.** The paving mixture shall be capable of filling up to 40 mm (1 1/2 inch) wheel ruts in one pass, be capable of field regulation of the setting time, and be suitable for nighttime placement. The compatibility of all ingredients of the mix, including the mix set additive, shall be certified by the emulsified asphalt manufacturer.

**448.05 Proportioning.** An independent laboratory provided by the Contractor shall develop the Job Mix Formula (JMF) for the paving mixture, shall verify the functioning of the set regulating additives, and shall present certified test results for the Engineer's approval. The JMF shall have a minimum Marshall Stability of 8 kN (1,800 lbs.) and a flow of 1.5 to 4 mm (6 to 16 units) when tested according to ASTM D 1559 except air drying of the mixture at 20-25 °C (70-75 °F.) for 3 days before reheating and placing the material in the test molds will be permitted. Aggregate in the mixture shall represent material to be used on the project.

Proportions for the JMF shall be within the following limits:



Mineral Aggregate, dry mass (weight) kg per m <sup>2</sup>	8-30
Latex Emulsified Asphalt Residue, % by wt. of Aggregate	6.0-8.0
Latex Base Modifier	As required with % by mass (weight) of Binder min. of 2.5
Mix Set Additive	As required
Mineral Filler, % by mass (weight) of Aggregate	0.5-2.5, depending on weather conditions

The Engineer shall approve the JMF prior to its use. After approval, the Contractor shall maintain continuous control of the latex modified emulsified asphalt to dry aggregate proportioning to conform to the approved JMF within a tolerance of  $\pm 8$  L/metric ton ( $\pm 2$  gals. per ton).

**448.06 Weather Limitations.** The mixture shall be placed only when it is not raining, and when the temperature is at least 5 °C (40 °F.) and rising and the forecast for the next 24 hours is above 0 °C (32 °F.). Applications after October 31 and before March 31 will not be permitted when the temperature is less than 10 °C (50 °F.).

**448.07 Surface Preparation.** Prior to applying the mixture, the Contractor shall clean the surface by removing vegetation, loose materials, dirt, mud and other objectionable materials. Water shall be misted on the existing pavement surface immediately prior to applying the asphalt mixture. A tack coat will be required on portland cement concrete surfaces. The tack coat shall be limited to emulsified asphalts as outlined in Article 406.02 and shall be applied at a rate of 0.22-0.45  $L/m^2$  (0.05-0.10 gal. per sq. yd.) according to Article 406.06(b).

**448.08 Application.** If rut filling is called for on the plans, the micro-surfacing shall be performed in 2 operations. The first operation shall include filling each of the 2 wheelpath ruts in a lane using the specially designed rutbox and the rutfill mix. The second operations shall include a simple application of the surface mix over the entire width of the lane and spread at a rate to provide a minimum of 8 kg/m² (15 lbs. per sq. yd.) of aggregate (dry weight) in the mixture. It shall be the Contractor's responsibility to determine and estimate the quantities of rutfill mix required for rut filling.

For other than rut filling, the micro-surfacing shall consist of the application of the surface mix over the entire width of each lane in 2 passes to provide a total rate of application of not less than 16 kg/m² (30 lbs. per sq. yd.) of aggregate (dry weight) in the mixture. The rate of application per pass may vary somewhat from one half the total minimum rate at the option of the Contractor. For example, the Contractor may choose to place the surface mixture at a rate to provide 6.5 kg/m² (12 lbs. per sq. yd.) of aggregate (dry weight) on the first pass and 10 kg/m² (18 lbs. per sq. yd.) on the second pass. Unless otherwise directed by the Engineer, all hand work shall be completed during the first pass.

Determinations of application rates shall be from daily readings taken from the material control devices during the progress of the work.

Micro-surfacing edges shall be parallel with the existing pavement edges. If the existing pavement edge cannot be used to give a straight edge, a string line or other guide will be required.

The paving mixture shall be spread to fill minor cracks and shallow potholes and leave a uniform surface. Care shall be taken when rut filling to restore the designed profile of the pavement cross section. Excess crowning (over-filling) of rut areas shall be avoided. A sufficient amount of material shall be carried at all times in all parts of the spreader box to ensure complete coverage. No lumps or unmixed aggregate will be permitted in the finished surface.

A smooth, neat seam shall be provided where two passes meet. Excess material shall be immediately removed from the ends of each run. Any damage to, or irregularities in, the micro-surfacing shall be repaired by the Contractor at his/her own expense, as directed by the Engineer. All repairs shall be made with a paver box, except areas designated as hand work areas.

Those areas in accessible to the spreader box and other areas approved by the Engineer shall be designated as hand work areas. Adjustments to the additive are permitted to provide a slower setting time when hand spreading is needed. If hand spreading is necessary, the mixture shall be poured in a small windrow along one edge of the surface to be covered and then spread uniformly by a hand squeegee or lute.

**448.09 Sampling and Testing.** The Contractor shall be responsible for all sampling and testing, and for furnishing all test results to the Engineer. The Contractor, in the presence of the Engineer, shall take a minimum of 2 samples per day for extraction/gradation analyses. The samples shall be taken from the pug mill discharge chute using a rectangular non-absorptive container, such as a loaf pan, of sufficient size to obtain a sample from the entire cross section of the mixture being discharged. Each sample should weigh from 1000 to 1500 gms (2.5 to 4 lbs.). Each sample shall be tested to determine the asphalt content and gradation of aggregate

in the mixture. The testing shall be performed according to the requirements of the Department's "Manual of Instructions for Bituminous Proportioning and Testing".

**448.10 Opening to Traffic.** Micro-surfacing shall be capable of producing an emulsified asphalt paving mixture that will cure at a rate which will permit traffic on the pavement within one hour after application without damaging the pavement surface. Any damage done by traffic to the micro-surfacing shall be repaired by the Contractor at his/her expense.

## 448.11 Method of Measurement.

- (a) Contract Quantities. The requirements for the use of contract quantities shall conform to Article 202.07(a).
- (b) Measured Quantities. When rut filling is called for, micro-surfacing for the surface mix placed in 1 pass will be measured for payment in place and the area computed in square meters (square yards). The width for measurement will be the width of the top surface as shown on the plans or as directed by the Engineer. Micro-surfacing for rut filling will be measured for payment in place in meters (feet) along the wheel path or filled rut.

For other than rut filling. The plans, micro-surfacing for the surface mix placed in 2 passes will be measured for payment in place as specified above for the surface mix placed in 1 pass.

**448.12 Basis of Payment.** When rut filling is called for, this work will be paid for at the contract unit price per square meter (square yard) for MICRO-SURFACING 1 PASS and per meter (foot) for MICRO-SURFACING RUT FILLING.

When rut filling is not needed or called for on the plans, this work will be paid for at the contract unit price per square meter (square yard) for MICRO-SURFACING 2 PASSES.

The above prices shall be considered as payment in full for the work complete in place, including the furnishing of all materials, (including tack coat if required) labor, equipment and incidentals necessary to complete the work as specified herein.

# SECTION 449. REMOVAL AND REPLACEMENT OF PREFORMED ELASTOMERIC COMPRESSION JOINT SEAL

- **449.01 Description.** This work consists of removing the existing joint seal and replacing it with a new preformed elastomeric compression joint seal of the size shown in the plan details and as directed by the Engineer.
- **449.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 Materials:

**449.03 Equipment.** The machine used to cut the joints shall be an approved concrete saw. Routers or saws which produce rough and raveled joint faces will not

be allowed. The machine shall also be capable of cutting a uniform shape in a straight manner so that the seal will seat properly in the joint.

## **CONSTRUCTION REQUIREMENTS**

**449.04 General.** The existing joint seal shall be removed prior to reshaping the joint or shall be saw cut out during reshaping of the joint. The preformed elastomeric compression joint seal shall be installed in a clean joint according to Article 420.14(b).

## 449.05 Method of Measurement.

- (a) Contract Quantities. The requirement for use of contract quantities shall be according to Article 202.07(a).
- (b) Measured Quantities. Removal and replacement of preformed elastomeric compression joint seal will be measured for payment in meters (feet), measured along the joint.
- **449.06** Basis of Payment. Removal and replacement of preformed elastomeric compression joint seal will be paid for at the contract unit price per meter (foot) for REMOVAL AND REPLACEMENT OF PREFORMED ELASTOMERIC COMPRESSION JOINT SEAL, which price shall include all work specified.

## **SECTION 450. RELIEF JOINT**

**450.01 Description.** This work shall consist of removing the existing pavement to the width specified, installing a preformed expansion joint filler and sealing as specified herein.

**450.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 - Materials:

	Item	Article/Section
(a)	Hot Poured Joint Sealer	1050.02
(b)	Preformed Expansion Joint Filler	

## 450.03 Equipment.

- (a) Concrete Saw. Concrete saws shall be equipped with a diamond blade of sufficient size to saw pavements full-depth and be capable of accurately maintaining cutting depth and alignment.
- (b) Wheel saw. Wheel saws shall be equipped with carbide tipped rotating cutters and be capable of accurately maintaining cutting depth and alignment.
- (c) Heating Equipment for Joint Sealant. The heating equipment shall be of an indirect heating type with positive temperature control, mechanical agitation and recirculating pumps.

Relief Joint Art. 450.04

## CONSTRUCTION REQUIREMENTS

**450.04 General.** The relief joint shall be formed by full-depth sawing of the existing pavement. The joint shall be straight and perpendicular to the centerline, with a tolerance of 40 mm in 3.6 m (1 1/2 inches in 12 ft.). Concrete not sawed full depth shall be removed with hand tools.

Prior to installing the preformed expansion joint filler, the sawed faces of the pavement shall be cleaned with compressed air. If the sawing operation disturbs or displaces the subbase, the disturbed subbase shall be removed and replaced with compacted FA-1 or FA-2 to the bottom of the existing pavement.

The preformed expansion joint filler shall be installed in a compressed condition in the sawed joint. The method used shall minimize damage to the filler.

The hot poured joint sealer shall be installed as shown on the plans and in the saw cut extensions. Poured joint sealing material shall be placed according to Article 420.14(a). The joint sealer shall cure to the satisfaction of the Engineer prior to opening to traffic.

Wheel saw cut extension or other large areas removed from the shoulders shall be replaced with the same material as in the existing shoulder before opening to traffic.

- **450.05 Method of Measurement.** This work will be measured for payment in meters (feet) along the joint from edge to edge of pavement.
- **450.06 Basis of Payment.** This work will be paid for at the contract unit price per meter (foot) for RELIEF JOINT of the width specified. If the sawed joint closes and the Engineer requires resawing the joint, this resawing will be paid for according to Article 109.04.

# SECTION 451, CRACK SEALING BITUMINOUS PAVEMENT

- **451.01 Description.** This work shall consist of routing, cleaning and sealing transverse and longitudinal reflected cracks in the existing bituminous pavement.
- **451.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 Materials:

	Item	Article	e/Section
(a)	Hot Poured Joint Sealer		1050.02

**451.03 Equipment.** The routing machine to be used for routing cracks and joints shall have a cutter that consists of radially located steel cutters mounted on a circular cutter head. The routing machine shall also be capable of cutting a uniform square shape approximately 20 mm by 20 mm (3/4 inch by 3/4 inch) in either a straight or irregular line. A double-jacketed kettle shall be used for heating the sealer.

## **CONSTRUCTION REQUIREMENTS**

**451.04 General.** Primary transverse and longitudinal working cracks shall be routed, cleaned and sealed. Any adjacent secondary cracks shall be only cleaned

and sealed as directed by the Engineer.

Cracks shall be routed following the crack as nearly as possible, approximately 20 mm (3/4 inch) wide by 20 mm (3/4 inch) deep as close to a 1:1 ratio as possible. Immediately ahead of sealer placement, dust and debris shall be blown from the crack with a power brush/blower or with compressed air with a minimum pressure of 620 kPa (90 psi). If compressed air is used, the pneumatic tool lubricator must be bypassed and a filter installed on the discharge valve to keep water and oil out of the lines.

The sealant shall be applied using the methods and equipment recommended by the sealant manufacturer. Hot asphalt sealer shall be continuously, mechanically agitated during heating so that localized heating does not occur. Poured crack sealer shall not be placed when the air temperature in the shade is less than 4 °C (40 °F.).

Sealant shall be placed in the clean, dry crack. The crack shall be slightly overfilled and immediately squeegeed to provide a "band-aid" type effect approximately 50 mm (2 inches) wide flush with the pavement surface with the edges feathered out.

The sealant shall be allowed to cure before opening to traffic. The sealant should be tack free in about 10 minutes. When necessary, the sealant may be dusted with fine sand, portland cement or mineral filler, or covered with tissue paper to prevent tracking.

### 451.05 Method of Measurement.

- (a) Crack Routing. Routed cracks will be measured for payment in meters (feet), measured along the routed crack.
- (b) Crack Filling. Filling of cracks will be measured for payment in kilograms (pounds) of sealant used. The cost of cleaning the crack shall be included in the price bid for crack filling. The quantity of sealant used will be determined by counting the containers of sealant used, multiplied by the indicated kilograms (pounds) of each container.
- **451.06 Basis of Payment.** This work will be paid for at the contract unit price per meter (foot) for CRACK ROUTING (PAVEMENT) and at the contract unit price per kilogram (pound) for CRACK FILLING, which prices shall include routing and cleaning the cracks and furnishing and pouring the sealant.

# SECTION 452. CRACK AND JOINT SEALING PORTLAND CEMENT CONCRETE PAVEMENT

- **452.01 Description.** This work consists of routing, cleaning and sealing longitudinal shoulder joints, transverse and longitudinal random cracks, centerline joints, contraction joints and transverse expansion joints in P.C. concrete pavement.
- **452.02 Materials.** Materials shall meet the requirements of the following Article of Section 1000 Materials:

	Item	Article/Section
(a)	Hot Poured Joint Sealer	

**452.03 Equipment.** The routing machine to be used for routing cracks and joints shall have a cutter that consists of radially located steel cutters mounted on a circular cutter head. The routing machine shall also be capable of cutting a uniform square shape approximately 20 mm by 20 mm (3/4 inch by 3/4 inch) in either a straight or irregular line. A double-jacketed kettle shall be used for heating the sealer.

#### **CONSTRUCTION REQUIREMENTS**

**452.04 General.** The longitudinal shoulder joint between the edge of pavement and the newly placed bituminous shoulder, the transverse and longitudinal random cracks in other than continuously reinforced pcc pavement, contraction joints and the centerline joints shall be routed or sawed to approximately 20 mm (3/4 inch) wide by 20 mm (3/4 inch) deep as close to a 1:1 ratio as possible. When routing or sawing the longitudinal shoulder joint, the router or saw used shall be capable of following the path of the joint without causing excessive spalling or damage to the adjacent rigid pavement. If old sealants are present in the joint or crack, they shall be removed prior to routing or sawing.

Immediately ahead of the sealer placement, dust and debris shall be blown from the joint or crack with a power brush/blower or with compressed air at a minimum pressure of 620 kPa (90 psi). If compressed air is used, the pneumatic tool lubricator must be bypassed and a filter installed on the discharge valve to keep water and oil out of the lines.

Hot asphalt sealer shall be continuously, mechanically agitated during heating so that localized heating does not occur. Poured crack sealer shall not be placed when the air temperature in the shade is less than 4 °C (40 °F.).

Areas along the longitudinal shoulder joint, the transverse and longitudinal random cracks (where applicable), the contraction joint or centerline where a void exists that exceeds 20 mm (3/4 inch) depth shall be provided with a backer rod to control the depth of sealant. The void shall be routed (if necessary) to provide a depth from the top of the backer rod to the top of the pavement of 20 mm (3/4 inch).

The areas where backer rod will be required shall be as directed by the Engineer. The backer rod diameter shall be 3 mm (1/8 inch) wider than the routed joint. The backer rod shall be a closed-cell, plastic-foam, heat resistant, chemically inert, waterproof, rod compatible with the sealant used.

Sealant shall be placed in the clean, dry crack or joint. The crack or joint shall be slightly overfilled and immediately squeegeed to provide a "band-aid" type effect approximately 50 mm (2 inches) wide flush with the pavement surface with the edges feathered out.

The sealant shall be allowed to cure before opening to traffic. The sealant should be tack free in about 10 minutes. When necessary, the sealant may be dusted with sand or covered with tissue paper to prevent tracking.

The procedure for routing, cleaning and sealing longitudinal random cracks will be the same as the longitudinal shoulder joint, except the crack reservoir shall be sealed flush rather than providing an oversealed or "band-aid" type effect.

Transverse expansion joints shall be routed to create an approximate 25 mm (1-inch) deep reservoir. The walls of the joint shall be cleaned and refaced. The

reservoir shall be filled flush with sealant.

#### 452.05 Method of Measurement.

- (a) Joint or Crack Routing or Sawing. Routed or sawed joints or cracks will be measured for payment in meters (feet) measured along the routed or sawed joint or crack.
- (b) Joint or Crack Filling. Filling of joints or cracks will be measured for payment in kilograms (pounds) of sealant used. The amount of sealant used will be determined by counting the containers or sealant used, multiplied by the indicated kilograms (pounds) of each container.
- **452.06 Basis of Payment.** This work will be paid for at the contract unit price per meter (foot) for JOINT OR CRACK ROUTING (PC CONCRETE PAVEMENT AND SHOULDER) and JOINT OR CRACK ROUTING BITUMINOUS SHOULDER, and at the contract unit price per kilogram (pound) for JOINT OR CRACK FILLING.

Furnishing and installing backer rod when required by the Engineer will be paid for according to Article 109.04.

#### SHOULDERS

### **SECTION 480. EARTH SHOULDERS AND MEDIANS**

**480.01 Description.** This work shall consist of placing, compacting, shaping and finishing earth, which is free from vegetation, roots, sod and other objectionable material, used in the construction of shoulders and medians.

### CONSTRUCTION REQUIREMENTS

**480.02 General.** The Contractor shall at all times perform construction operations for the shoulders and medians in a manner such that the finished pavement, base or surface course, curb, gutter, curb and gutter, or any drainage structure will not be damaged by any of the equipment used. If the Engineer deems it necessary, the Engineer may require that all joints and edges be protected with a covering of earth, or by some other adequate means. If any completed or partially completed portion of the improvement, or any existing structure or portion thereof which is to remain in place is damaged or defaced during construction of the shoulders and medians, it shall either be repaired or removed and replaced by and at the expense of the Contractor, and to the satisfaction of the Engineer.

The shoulders and medians may be constructed and finished with a blade grader. The earth in shoulder and median areas shall be compacted as specified in Article 205.06, except that the earth in the area between curb or gutter and sidewalk shall be compacted in a manner meeting the approval of the Engineer. Prior to final blading and shaping of the shoulders and medians, they shall be rolled with a pneumatic-tired roller meeting the requirements of Article 1101.01.

- **480.03** Rigid Type Surfacing, Curb, Gutter, or Curb and Gutter. At locations where shoulders or medians are constructed adjacent to a portland cement concrete pavement, portland cement concrete base course, curb, gutter, or curb and gutter, placing of the earth for the shoulders or medians shall be completed and the earth compacted, shaped and finished to the lines, grades and cross sections shown on the plans after the surfacing, curb, gutter, or curb and gutter has been constructed.
- **480.04 Nonrigid Type Surfacing.** At locations where shoulders or medians are constructed adjacent to nonrigid type surfacing such as aggregate base or surface course, or any bituminous surface course not constructed on a portland cement concrete base course, the following shall apply:
  - (a) When the Base or Surface Course is constructed in a trench. Before the material for the base or surface course is deposited, earth shall be roughed in for the shoulders. The earth shall be placed so that it will be possible to retain and compact the edges of the base or surface course. After the base or surface course has been constructed, the balance of the earthwork required to complete the shoulders and median shall be performed, and the shoulders and median shall be shaped and trimmed to the lines, grades and cross sections shown on the plans.
  - (b) When the Base or Surface Course is not constructed in a trench. Before the base or surface course is constructed, the earthwork required to complete the shoulders and median shall be shaped and trimmed to the lines, grades and cross sections shown on the plans.

**480.05 Basis of Payment.** This work will not be measured or paid for separately, but shall be considered as included in the contract unit price bid for the particular type of surface course, base course, or widening included in the contract.

# **SECTION 481. AGGREGATE SHOULDERS**

- **481.01 Description.** This work shall consist of furnishing, placing, shaping and compacting aggregate placed along the edges of the completed pavement structure.
- **481.02 Materials.** Materials shall meet the requirements of the following Article of Section 1000 Materials:

_		Item	Article/Section
(a) A	Aggregate		1004.04

**481.03 Equipment.** Equipment shall meet the requirements of the following Articles of Section 1100 - Equipment:

	Item A	rticle/Section
(a)	Tamping Roller	1101.01
(b)	Pneumatic-Ttired Roller	1101.01
(c)	Three-Wheel Roller	1101.01
(d)	Tandem Roller	1101.01
(e)	Vibratory Machine (Note 1)	
(f)	Spreader	1102.04

Note 1. The vibratory machine shall meet the approval of the Engineer.

## **CONSTRUCTION REQUIREMENTS**

- **481.04 General.** The road shall be opened to traffic according to Article 701.05(a)(1).
  - (a) Aggregate Shoulders, Type A. Before placing the aggregate, weeds and grass on the area to be covered shall be cut and removed and the subgrade prepared in a manner approved by the Engineer. Before the aggregate is deposited on the subgrade, it shall contain sufficient moisture to provide satisfactory compaction. The water and aggregate shall be mixed at a central mixing plant. The plant shall be equipped with a mechanical mixing device, and aggregate and water measuring devices, meeting the approval of the Engineer. Wetting the aggregate in cars, bins, stockpiles or trucks will not be permitted.

The shoulders shall be constructed in layers of not more than 100 mm (4 inches) thick when compacted, except that if tests indicate the desired results are being obtained, the compacted thickness of any layer may be increased to a maximum of 200 mm (8 inches). The aggregate shall be deposited directly on the prepared subgrade or on the preceding layer of compacted aggregate with a spreader.

Each layer of material shall be compacted with a tamping roller, or with a pneumatic-tired roller, or with a vibratory machine, or with a combination



of any of the 3 until the compaction has been approved by the Engineer. If the moisture content of the material is not such as to permit satisfactory compaction during the compacting operations, water shall be added in such quantity that satisfactory compaction can be obtained. The top layer shall be given a final rolling with a three-wheel or tandem roller. Three-wheel or tandem rollers shall weigh from 5.5 to 9 metric tons (6 to 10 tons) and not less than 35 N/mm (200 lbs. per inch) nor more than 55 N/mm (325 lbs. per inch) of width of the roller.

If any subgrade material is worked into the aggregate during the compacting or finishing operation, all granular material within the affected area shall be removed and replaced with new aggregate.

The shoulders shall be constructed to the thicknesses shown on the plans. Thickness determinations shall be made at such points as the Engineer may select. When the constructed thicknesses are less than 90 percent of the thicknesses shown on the plans, aggregate shall be added to obtain the required thicknesses; however, the surface elevation of the completed shoulders shall not exceed by more than 3 mm (1/8 inch) the surface elevation shown on the plans or authorized by the Engineer.

(b) Aggregate Shoulders, Type B. The aggregate shall be deposited in its final position with a spreader and compacted to the satisfaction of the Engineer. If the moisture content of the aggregate is not such as to permit satisfactory compaction during the rolling operations, water shall be added in such quantity that satisfactory compaction can be obtained.



**481.05 Method of Measurement.** The aggregate for constructing the shoulders will be measured for payment in metric tons (tons), in cubic meters (cubic yards), in square meters (square yards), or according to the requirements of Article 311.08, except that payment will not be made for aggregate outside the plan width. The unit of measurement will be as shown on the plans.

**481.06 Basis of Payment.** This work will be paid for at the contract unit price per metric ton (ton) for AGGREGATE SHOULDERS, TYPE A, or AGGREGATE SHOULDERS, TYPE B; or at the contract unit price per cubic meter (cubic yard) for AGGREGATE SHOULDERS, TYPE A, or at the contract unit price per square meter (square yard) for AGGREGATE SHOULDERS, TYPE A, of the thickness specified. Any earthwork required for placement of aggregate shoulders shall be included in the contract unit price bid for aggregate shoulders of the type specified.



### **SECTION 482. BITUMINOUS SHOULDERS**

**482.01 Description.** This work shall consist of constructing a bituminous shoulder on a prepared subgrade, existing paved shoulder, or subbase.

**482.02 Materials.** Materials shall meet the requirements of Article 312.03, except that aggregate which does not meet the requirements of Article 1004.04(c) and liquid asphalt MC-3000 will not be permitted.

For the 50-mm (2-inch) top lift, the aggregate used shall meet the gradation requirements for a CA 10. Blending of aggregates at the plant in order to meet the

requirements for a CA 10 or CA 12 will be permitted.

**482.03 Equipment.** The equipment shall meet the requirements of Article 312.04.

## CONSTRUCTION REQUIREMENTS

#### 482.04 General.

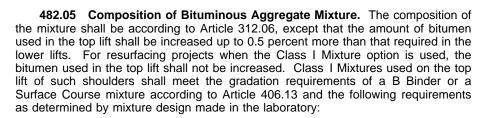
For pavement and shoulder resurfacing projects, Class I Binder and Surface Course (Type 1 or Type 2) mixtures may be used in lieu of Bituminous Aggregate Mixture for the resurfacing of shoulders, at the option of the Contractor.

For the construction of safety shoulders for pavement resurfacing, Class I Binder and Surface Course mixtures shall be used.

The methods used in performing this work shall meet the following requirements:

	Item Article	Section /
(a)	General Conditions	312.05
(b)	Preparation of Bituminous Material	312.07
(c)	Preparation of Bituminous Aggregate Mixture	312.08
	Transportation of Bituminous Aggregate Mixture	

Whenever bituminous shoulders are constructed adjacent to a pavement constructed on an improved subgrade and additional material is needed to extend the improved subgrade to the bottom of the bituminous shoulder, the additional material shall be subbase granular material, Type C, conforming to Section 311. The work of constructing this additional thickness of material will not be paid for separately, but shall be considered as included in the contract unit price bid for the item of the improved subgrade.



## 50-Blow Marshall Mix Design

Min.	Maximum
Stability kN (lbs.)	Flow 0.25 mm (0.01 inches)
6.6 (1500)	19

For safety shoulder construction, the composition of the Class I Binder and surface course shall be the same as that specified for the main line pavement.

**482.06** Placing and Compacting. This work shall be accomplished according to Article 312.10, except the density of the first layer shall be not less than 90 percent of the theoretical density and subsequent layers shall be compacted to not less than



92 percent of the theoretical density. The density shall be obtained by an approved vibratory compactor and a roller or by the use of two rollers. If the Contractor demonstrates an alternate method of compaction that will result in obtaining the required density, it may be used subject to the approval of the Engineer as provided in Article 108.06. The top lift shall be a nominal 50-mm (2-inch) compacted layer. The mechanical spreader for the top 50-mm (2-inch) lift of shoulders shall meet the requirements of Article 1102.03 when the shoulder width is 3 m (10 ft.) or greater. The bottom lift or lifts of shoulders shall be placed with a machine operated on the pavement.

When the Class I mixture option is used on resurfacing projects, shoulder resurfacing widths of 1.8 m (6 ft.) or less may be placed, at the Contractor's option, simultaneously with the adjacent traffic lane for both the binder and surface courses, provided the specified density, thickness and cross slope of both the pavement and shoulder can be satisfactorily obtained. The paver shall operate with both tracks/drive wheels on the traffic lane. Shoulder resurfacing greater than 1.8 m (6 ft.) in width shall be placed in a separate operation.



When rumble strips are required, they shall be formed by use of a modified roller drum after finish rolling. The drum roller shall be modified to create a rumble strip pattern shown on the plans. The Contractor shall have the option of using either continuous or intermittent corrugations. The corrugations shall be perpendicular to the pavement edge and shall be omitted when falling within the limits of a side road, entrance or ramp entrance and exit. The roller shall be equipped with a sighting device to enable the operation to maintain proper alignment, and shall have a minimum weight of 9 metric tons (10 tons) or be of sufficient weight to obtain the desired results as directed by the Engineer. After the rumble strips are formed, a final pass with a finish roller shall be made when directed by the Engineer.



The Class I Binder portion of safety shoulders constructed simultaneously with pavement resurfacing may be constructed in 1 or 2 lifts. If the plans call for the pavement to be resurfaced with Class I Surface Course only, the entire safety shoulder may be constructed with surface course, except that the portion normally constructed with binder shall be placed and compacted separately.

**482.07 Tolerance in Thickness.** The shoulder shall be constructed to the thickness shown on the plans. When the contract includes square meters (square yards) as the unit of measurement for Bituminous Shoulder, thickness determinations shall be made at such points as the Engineer may select. When the constructed thickness is less than 90 percent of the specified thickness, it shall be brought to specified thickness by the addition of the applicable mixture or by removal and replacement with a new mixture. However, the surface elevation of the completed shoulder shall not exceed by more than 3 mm (1/8 inch) the surface elevation shown on the plans or authorized by the Engineer.

#### 482.08 Method of Measurement.

- (a) Contract Quantities. The requirements for the use of Contract Quantities shall conform to Article 202.07(a).
- (b) Measured Quantities. When bituminous shoulders are constructed along the edges of the completed pavement structure, bituminous shoulders will be measured for payment in place and the area computed in square meters (square yards). The width for measurement will be from the edge of the

pavement to the top edge of the bituminous shoulder as shown on the plans or as directed by the Engineer.

On pavement and shoulder resurfacing projects, bituminous shoulders will be measured for payment in metric tons (tons) according to the applicable portions of Article 406.23, except that the requirement that payment will not be made for any bituminous concrete mixture in excess of 103 percent of the quantity specified by the Engineer will not apply. When shoulder resurfacing is placed simultaneously with the adjacent traffic lane or when a bituminous wedge is placed simultaneously with the binder course on the traffic lane as specified in Article 406.20, the quantity of bituminous shoulders will be measured for payment as specified in Article 406.23.



The Class I binder and surface course mixtures used in construction of safety shoulders for pavement resurfacing will be measured for payment in metric tons (tons) as specified in Article 406.23, except that the thickness of surface course will be limited to that specified for the adjacent resurfacing. Surface course used in excess of this amount will be measured for payment as binder course.

**482.09 Basis of Payment.** When bituminous shoulders are constructed along the edges of the completed pavement structure, this work will be paid for at the contract unit price per square meter (square yard) for BITUMINOUS SHOULDERS of the thickness specified. The specified thickness shall be the thickness shown on the plans at the edge of the pavement.

On pavement and shoulder resurfacing projects, the shoulder resurfacing will be paid for at the contract unit price per metric ton (ton) for BITUMINOUS SHOULDERS.



The construction of safety shoulders for resurfacing pavements will be paid for at the contract unit price per metric ton (ton) for BITUMINOUS CONCRETE BINDER COURSE of the mixture and type specified, and for BITUMINOUS CONCRETE SURFACE COURSE, CLASS I, of the mixture and type specified.



# **SECTION 483. PORTLAND CEMENT CONCRETE SHOULDERS**

**483.01 Description.** This work shall consist of constructing a portland cement concrete shoulder on a prepared subgrade or subbase adjacent to the edges of the completed pavement structure.

**483.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 - Materials:

	Item	Article/Section
(a)	Portland Cement Concrete	1020
(b)	Tie Bars (Note 1)	1006.10
(c)	Poured Joint Sealer	1050
(d)	Protective Coat	1023.01

Note 1. Tie bars shall be epoxy coated.

**483.03 Equipment.** Equipment shall meet the requirements of the following Articles of Section 1100:

	Item	Article/Section
(a)	Forms for Pavement	1103.05
(b)	Form Grader	1103.06
(c)	Formless Paver	1103.16
(d)	Water Supply Equipment	1103.11
(e)	Batching and Weighing Equipment	1103.02, 1103.03
(f)	Paving Mixer (and Water Measuring Equipment)	1103.01
(g)	Truck Agitator	1103.01
(h)	Heavy Subgrade Template	1103.10
(i)	Mechanical Form Tamper	1103.07
(j)	Miscellaneous Equipment	1103.17
	Membrane Curing Equipment	1101.09

### **CONSTRUCTION REQUIREMENTS**

- **483.04 General.** Portland cement concrete shoulders shall be constructed according to the applicable portions of Articles 420.04 through 420.21 except as specified in the following articles.
- **483.05 Subgrade.** The work of constructing this additional thickness of material will not be paid for separately, but shall be considered as included in the contract unit price bid for the item of the improved subgrade.
- **483.06 Placing and Finishing.** If the placement of concrete shoulders requires mechanical equipment to operate on the adjacent lane of pavement, that lane shall have attained the strength specified for 14-day concrete. If only finishing equipment is to be operated on the edge of the adjacent lane, shoulder placement may be permitted after 3 days. Prior to placing the shoulders, all joints in the adjacent pavement shall be permanently sealed according to Article 420.14. The jute roping or soft cotton rope interim seal will not be permitted. In addition, the pavement edge at all transverse joints shall be sealed or caulked to prevent the intrusion of mortar from the shoulder placing operation into the joint.

If forms are used, they shall be set and removed according to Articles 420.06 and 420.13, respectively. A mechanical spreader and finishing machine will not be required. The concrete may be struck off and consolidated using a vibrating screed approved by the Engineer.

If the slip form method is used, the slip form paving equipment may operate from the adjacent lane or on tracks spanning the shoulder area. The slip form equipment shall vibrate the concrete either externally or internally with sufficient intensity to consolidate the concrete throughout its entire depth and width. The concrete shall be consolidated and finished true to grade and cross section in one pass in a manner such that a minimum of hand floating will be required. The tolerance for edge slump shall be according to Article 420.17(a).



Prior to the final finish, the shoulder shall be straightedge tested and corrected according to Article 420.11(c). When forms are used, the outer edge of the shoulder shall be finished with an edging tool. The final finish shall be according to Article 420.11(e)(1), Type A. If rumble strips are required, they shall be formed in the surface of the shoulder according to the details shown on the plans and in a manner

satisfactory to the Engineer immediately after the application of the final finish. The corrugations shall be perpendicular to the pavement edge and shall be omitted when falling within the limits of a sideroad, entrance or ramp entrance and exit.

**483.07 Joints.** The longitudinal construction joint between pavement and shoulder shall be tied with epoxy-coated deformed tie bars according to the details shown on the plans and as specified in Article 420.10(b). The joint shall be sealed as specified in Article 420.14.

Contraction and expansion joints in portland cement concrete shoulders shall be extensions of contraction and expansion joints in the adjacent pavement.



Transverse construction joints in concrete shoulders shall be constructed according to the details shown on the plans. For hinge jointed pavement, transverse construction joints shall be the prolongation of a hinge joint in the adjacent pavement. For other types of concrete pavement, transverse construction joints in the shoulder shall be located midway between shoulder contraction joints.

- **483.08 Surface Test.** The requirements of Article 420.12 for surface tests does not apply to portland cement concrete shoulders.
- **483.09 Tolerance in Thickness.** The shoulder shall be constructed to the thickness shown on the plans. Thickness determinations shall be made at such points as the Engineer may select. When the constructed thickness is less than 90 percent of the specified thickness, such thin shoulder shall be removed and replaced at the Contractor's expense.
- **483.10 Opening to Traffic.** The shoulders shall be open to traffic according to Article 701.05(a)(2).

#### 483.11 Method of Measurement.

- (a) Contract Quantities. The requirements for the use of contract quantities shall conform to Article 202.07(a).
- (b) Measured Quantities. Portland cement concrete shoulders will be measured for payment in place and the area computed in square meters (square yards). The width for measurement will be from the edge of the pavement to the edge of the portland cement concrete shoulder as shown on the plans or as directed by the Engineer.

The area of shoulder upon which the protective coat is applied will be measured for payment in place and the area computed in square meters (square yards).

**483.12** Basis of Payment. This work will be paid for at the contract unit price per square meter (square yard) for PORTLAND CEMENT CONCRETE SHOULDERS of the thickness specified. The specified thickness shall be the thickness shown on the plans at the edge of the pavement.

If a protective coat is applied, it will be paid for at the contract unit price per square meter (square yard) for PROTECTIVE COAT, which price shall be payment in full for cleaning the surface of the shoulder and for the 2 applications. No additional compensation will be allowed the Contractor if all or a portion of the quantity of

Protective Coat is deducted from the contract.

### **SECTION 500. STRUCTURES**

## **BRIDGES**

## **SECTION 501. REMOVAL OF EXISTING STRUCTURES**

**501.01 Description.** This work shall consist of the removal and satisfactory disposal of existing traffic and drainage structures or portions thereof, as specified.

## CONSTRUCTION REQUIREMENTS

**501.02** Complete Removal of Structures. Materials that are to be salvaged under the contract and which the Engineer deems fit for reuse shall be carefully removed in transportable sections and stockpiled near the site at a location designated by the Engineer. If the material for reuse is unfit, through no fault of the Contractor, the material shall be disposed of according to Article 202.03. When the Contractor damages or destroys such material, the Contractor shall repair or replace it at his/her own expense and in a manner satisfactory to the Engineer.

When specified that the superstructure is to be salvaged for reerection, all members and loose parts shall be properly matchmarked, all machined steel surfaces treated with an approved anti-rust compound, and all loose parts wired to adjacent members, or packed in marked boxes.

Materials that are not to be salvaged and stockpiled shall become the property of the Contractor and shall be removed and disposed of according to the requirements of Article 202.03.

Existing structures shall be removed to at least 300 mm (1 ft.) below the proposed elevation of subgrade or ground surface, within the area of construction and within the limits of the right of way. All portions of existing structures below this elevation that interfere in any way with the new construction, shall be removed.

The location, size, and type of existing culverts to be removed shall be as shown on the plans or as directed by the Engineer. When existing culverts are designated to be salvaged, the removal operation shall be performed in a manner that will not cause damage to the existing culvert.

Existing concrete slope wall shall be removed at the locations shown on the plans and as directed by the Engineer so all loose material shall be removed and disposed of as specified. It shall be the responsibility of the Contractor to determine the thickness of the slope wall to be removed and the extent to which it is reinforced. No additional compensation will be allowed because of variations from the assumed thickness or from the thickness shown on the plans, or for variations in the amount of reinforcement. When only partial removal of existing concrete slope wall is to be performed, the removal shall be performed according to Article 501.03.



**501.03 Partial Removal of Structures.** Where portions of existing structures are to remain in service, portions to be removed shall be removed in such a manner as to leave the structure undamaged and in proper condition for the use contemplated. Any damage to the portions remaining in service shall be repaired by the Contractor at his/her own expense. Old concrete or masonry shall be carefully removed to the lines designated unless otherwise directed by the Engineer. Prior to concrete removal, a saw cut approximately 20 mm (3/4 inch) deep shall be made

along all boundaries of full-depth removal areas adjacent to areas to remain in place. For slabs the boundaries of full-depth removal shall be saw cut on the top and bottom surfaces. The concrete shall then be removed with jackhammers not heavier than the nominal 20 kg (45 lb.) class and suitable hand tools. Final removal at the designated lines of full-depth removal shall be accomplished by 7 kg (15 lb.) chipping hammers or hand tools, with particular care being exercised at the bottom of the slab to avoid breakage beyond the designated removal line. Where existing bars are to extend from the remaining portions of existing structures into new construction, the concrete shall be removed so as to leave the projecting bars clean and undamaged. All newly exposed concrete and exposed reinforcement bars to be incorporated into new concrete shall be blast-cleaned. The surfaces presented as a result of this removal shall be reasonably true and even, with sharp straight corners that will permit a neat and workmanlike joint with the new construction or be satisfactory for the purpose intended. Where projecting bars are not to extend into the new construction, they shall be cut off flush with the surface to which the old concrete has been removed.



At the Contractor's option, hydrodemolition equipment meeting the requirements of Article 1101.11 will be permitted for partial removal of structures in lieu of the equipment specified above. Operation of the hydrodemolition equipment shall be performed and supervised by qualified personnel certified by the equipment manufacturer. Evidence of certification shall be presented to the Engineer. When partial-depth removal is required, the equipment shall be calibrated and set to remove sound concrete to the required depth. If sound concrete is being removed below the required depth, the Engineer will require the equipment to be recalibrated and reset. The Contractor shall be responsible for disposing of the runoff water generated by the hydrodemolition operation. Runoff water shall not be allowed to constitute a hazard on adjacent or underlying roadways or railroads, or to erode existing slopes.

When full deck removal is specified, tools used for breaking or removing concrete which is attached to or supported by portions of the structure that are to remain in service shall be limited to jackhammers or hydraulic hammers having a maximum rated striking energy of 1600 J (1200 ft. lbs.). Drop hammers or other free falling type equipment will not be permitted. The Contractor shall exercise care so as not to notch or gouge the top flanges with jackhammers or other tools. When transverse saw cutting of the deck is utilized for full deck removal, the Contractor shall mark on top of the concrete deck the locations of the top flanges of all the steel beams or girders, prior to any removal of the bridge deck. Saw cutting directly over the top of the beam or girder flanges will not be permitted. Any damage to the existing steel shall be repaired by the Contractor at his/her own expense. Repairs shall be made as directed by the Engineer.

Where existing box culverts are to be extended, the Contractor shall remove such portions of the existing headwalls, wingwalls and barrel at the ends to be extended as indicated on the plans. If no provision is made on the plans or elsewhere for removing the old headwalls and wingwalls at the ends to be extended, they shall be removed, either down to the top of the old barrel or to 300 mm (1 ft.) below the proposed elevation of the subgrade or ground line above the old headwalls and wingwalls. When the old headwalls and wingwalls are to be removed below the top of the old barrel, the reinforcing steel from the old portion of the culvert shall be bent into the new construction.

When the headwall is to be removed, it shall be disposed of in a manner approved by the Engineer and according to Article 202.03. The removal shall be performed so the existing pipe culvert to remain in place is not damaged. Any

damage to the existing culvert shall be repaired or replaced by the Contractor at his/her expense.

At locations designated by the Engineer, all earth and debris shall be removed from the invert of the portions of existing culverts which are to remain in place.

**501.04 Method of Measurement.** When paid for as a separate item, removal of existing structures, removal of existing superstructures, removal of existing concrete deck, and removal of existing concrete headwall for pipe culverts will be measured for payment in units of each at the location designated on the plans.

Slope wall removal will be measured for payment in place and the area computed in square meters (square yards) of concrete slope wall to be removed.

Removal of existing culverts will be measured in place in meters (feet) of existing culvert to be removed.

When paid for as a separate item, the removal of concrete or masonry for partial removal of structures will be measured for payment and the volume computed in cubic meters (cubic yards) of concrete or masonry to be removed.



**501.05 Basis of Payment.** When the contract contains a separate item and unit price per each for REMOVAL OF EXISTING STRUCTURES, REMOVAL OF EXISTING SUPERSTRUCTURES, or REMOVAL OF EXISTING CONCRETE DECK.

When provided in the contract, the removal of portions of concrete or masonry structures in the manner specified under Article 501.03, and the disposal of the materials, will be paid for at the contract unit price per cubic meter (cubic yard) for CONCRETE REMOVAL or for MASONRY REMOVAL.

Disposal of materials specified for salvage but deemed unfit for further use through no fault of the Contractor will be paid for according to Article 109.04.

If existing structures or existing concrete or masonry are specified to be removed and no separate items or unit prices for such removal are provided in the contract, payment for this work will be considered as included in the contract unit prices for other items of work involved, except as provided for Rock Excavation for Structures in Section 502.

Removal of existing pipe culvert concrete headwalls will be paid for at the contract unit price each for CONCRETE HEADWALL REMOVAL.

Removal of existing pipe culverts will be paid for at the contract unit price per meter (foot) for PIPE CULVERT REMOVAL.

Removal of existing slope wall will be paid for at the contract unit price per square meter (square yard) for SLOPE WALL REMOVAL.

When the Engineer directs that earth and debris be removed from culvert inverts, such removal will be paid for according to Article 109.04.

The cost of the removal and disposal of all other existing structures which are visible above ground and the Contractor could be reasonably expected to have knowledge of them, shall be considered as included in the contract unit price for the major item of work in the contract, and no additional compensation will be allowed. In the event existing structures or portions of existing structures are encountered

which cannot be removed by normal excavation procedures and are not shown on the plans or are not evident in the field and are required to be removed, the cost of such removal will be paid for according to Article 109.04.

### **SECTION 502. EXCAVATION FOR STRUCTURES**

**502.01 Description.** This work shall consist of the excavation required for the construction of all structures including all bailing, draining, pumping, sheeting; the construction of cofferdams, or temporary cribs if found necessary, and their subsequent removal; the disposal of all material obtained from such excavation; and backfilling to the level of the ground surface as it existed before any excavation was made by the Contractor.

### CONSTRUCTION REQUIREMENTS

- **502.02 Clearing, Tree Removal and Protection of Existing Plant Material.** Prior to starting excavation operations in any area, all clearing, tree removal and protection of existing plant material in that area shall be performed as specified in Section 201.
- **502.03 General.** Excavation for structures shall include all materials encountered, regardless of their nature.

Structure Excavation shall include all excavation except rock excavation or excavation within a cofferdam.

Cofferdam Excavation, when specified, shall include all excavation within the limits of a cofferdam, except rock excavation.

- Rock Excavation for Structures shall consist of the excavation of boulders 0.5 m³ (1/2 cu. yd.) in volume or greater and all rock in ledges, bedded deposits and conglomerate deposits exhibiting the physical characteristics and difficulty of rock removal as determined by the Engineer. After the Engineer has made the determination that the material qualifies as rock excavation, the Contractor may use any method he/she chooses including ripping to remove the rock excavation. Rock Excavation for Structures shall also include existing concrete, masonry, timber grillages, foundation piles and similar materials, which are not exposed to view and are not shown on the plans and for which payment is not otherwise provided.
- **502.04 Sequence of Operations.** The elevations of the bottoms of footings, as shown on the plans, shall be considered as approximate and the Engineer may order such changes in dimensions or elevations of footings as may be necessary to secure a satisfactory foundation. Where foundation piles are used, the excavation of each footing, as shown on the plans, shall be completed before the piles are driven. After the piles are driven, all loose and displaced material shall be removed to the bottom of the footing elevation.
- **502.05** Excavation in Rock. Where the footing excavation is in rock, the rock shall be excavated to the plan dimensions of the footing or foundation seal. No rock shall project inside of such dimension more than 50 mm (2 inches). Other rock excavation shall be as necessary for the construction of the structure, subject to the limitations for measurement for payment specified in Article 502.14. All cracks, voids, seams or other irregularities in the excavation shall be cleaned and filled with concrete

or grout as directed by the Engineer.

**502.06 Cofferdams.** Cofferdams shall consist of watertight enclosures surrounding excavations. When cofferdams are not specified in the contract documents and conditions are encountered where the excavation for the structure cannot be kept free of water for prosecuting the work by pumping and/or diverting water by the use of sheeting or dikes, the Contractor, with the written permission of the Engineer, will be permitted to construct a cofferdam.

The cofferdams shall be designed, constructed, and removed with the Engineer's approval. Cofferdams shall consist of engineered structural components consisting of timber, standard steel sheet pile sections, structural steel sections, cylindrical metal shells, or a combination of the above. Earthen embankments or dikes will not be classified as cofferdams.

The Contractor shall submit drawings and design calculations showing the proposed design, method of construction, removal, as well as other details left open to choice or not fully detailed on the plans. The design and method of construction shall provide, within the measurement limits specified in Article 502.14, necessary clearance for forms, inspection of exterior of the forms, pumping, protection of fresh concrete from rising water, and protection of the footing from erosion. No component of the cofferdam shall extend into the substructure concrete without written permission of the Engineer. These drawings shall be submitted to the Engineer and approved prior to the start of construction. This approval shall not relieve the Contractor of responsibility of the cofferdam.

- (a) Foundation Seal. Foundation seal coats shall be constructed according to Article 503.15. When a cofferdam and seal coat are added to the contract by written permission of the Engineer, the design of the seal coat, including design calculations, shall be included in the overall design of the cofferdam when submitted to the Engineer for review and approval.
  - When the excavation within the cofferdam has been completed and piles have been driven, the elevation of the bottom of the cofferdam shall be determined by soundings. The equipment and methods used to conduct the soundings shall meet the approval of the Engineer. Any material higher than the plan elevation of the bottom of seal coat shall be removed.
- (b) Removal. Removal shall be according to the previously approved procedure. Unless otherwise approved in writing by the Engineer, all components of the cofferdam shall be removed.
- **502.07 Excavation Other Than Rock.** When the structure excavation occurs in material other than rock, the limits of the excavation shall not exceed the dimensions specified in Article 502.14. These limits may be exceeded only with the permission of the Engineer and subject to the limitations for measurement for payment specified in Article 502.14. The depth of the excavation shall be carried to the plan bottom of the footing elevation. If the material encountered at the plan bottom of the footing elevation is soft, muddy, or otherwise unsuitable, the material shall be removed to an additional depth as directed by the Engineer and replaced with crushed stone, gravel or other material approved by the Engineer.
- **502.08 Pumping.** Pumping from the interior of a foundation enclosure shall be done in a manner approved by the Engineer. Pumping will not be allowed during

placement of the concrete or for a period of 24 hours after completion of the placement, unless the pumping is accomplished from a watertight sump separated from the concrete being placed. Pumping to dewater a sealed cofferdam shall not begin until the seal coat has attained the design strength.

**502.09 Inspection.** After each excavation is completed, the Contractor shall notify the Engineer. No concrete shall be placed until after the Engineer has approved the depth of the excavation and the character and condition of the foundation material. When ordered in writing by the Engineer, the bottom of the excavated space within any cofferdam in which a foundation seal is to be constructed shall be inspected by a qualified diver, employed by the Contractor, and paid for according to Article 109.04. In such cases, the Department will not pay for any services performed by the diver other than the inspection.

**502.10 Backfilling.** Backfilling shall consist of placing and compacting the necessary fill within the space excavated for a structure below the ground surface as it existed before any excavation was made by the Contractor. Fill required above the ground surface as it existed prior to excavation for the structure is considered as embankment. Bracing, forms and rubbish shall be removed from the excavation before the backfill is placed. Unless sheeting is to remain in place, it shall be removed at such time as directed by the Engineer to best prevent loosening unexcavated material and facilitate placing and compacting the backfill. Sloping sides of the excavated space to cause objectionable wedging action of the backfill against the structure, shall be stepped or serrated to prevent such action.

Where the original ground surface is higher than the proposed elevation of roadway surface, stream banks or channels, the backfill shall be constructed up to the elevation designated as the proposed ground surface.

Backfill which is to serve as a roadbed, or upon which embankment is to be placed, shall be constructed by materials satisfactory to the Engineer. No sod, frozen material or any material which, by decay or otherwise, might cause settlement, shall be placed or allowed to remain in the backfill at such locations. Whenever the material obtained from the excavation is suitable, it shall be used in constructing the backfill. Excavated material that is unsuitable for backfill only because it contains too much moisture shall be allowed to dry before being used as backfill. Excavated material unsuitable for backfill shall be disposed of as specified in Article 502.11. If the amount of suitable excavated material is insufficient, suitable material shall be obtained and used for making or completing the backfill. When additional material is required, it shall be paid for as specified in Article 502.15.



In placing backfill or embankment, the material shall be placed simultaneously insofar as possible to approximately the same elevation on both sides of a wall, pier or column. If conditions require placing backfill or embankment appreciably higher on one side of a wall, pier or column than on the opposite side, the additional material on the higher side shall not be placed until test specimens show that the concrete has attained a flexural strength of 4.5 MPa (650 psi), but in no case until at least 7 days have elapsed after the placing of the concrete. In the absence of tests to determine the flexural strength, the additional material on the higher side shall not be placed until at least 14 days have elapsed after the placing of the concrete, exclusive of days on which the temperature of the air surrounding the concrete falls below 7 °C (45 °F.).

Behind abutments held at the top by the superstructure, no backfill or embankment shall be placed above the elevation of the backfill in front of such

abutments until the superstructure is in place, the concrete cured and falsework removed from concrete spans. Backfill or embankment shall not be placed behind the walls of concrete culverts until the top slab is placed and cured. Backfill and embankment behind abutments held at the top by the superstructure, and behind the sidewalls of culverts having a clear height of more than 1.5 m (5 ft.), shall be carried up simultaneously behind opposite abutments or sidewalls, and at no time shall the fill behind one abutment or sidewall be more than 600 mm (2 ft.) higher than behind the opposite one.

Backfill shall not be placed in water at closed abutments, culverts or retaining walls. The excavated area around these structures shall be pumped dry, and any mud or loose material within the excavated area shall be removed before placing backfill. At piers, backfill may be placed in water, providing no roadway embankment or slope wall is to be supported by the backfill and provided that both the water level and backfill are kept at approximately the same elevation on opposite sides of the pier. A time interval, approved by the Engineer, shall elapse before placing additional fill on one side of the pier, above the water surface.

Mechanical compaction of backfill will not be required around piers upon which no roadway embankment, slope wall or other highway appurtenance is to be placed and at those locations that are not adjacent to a highway, railroad or other improvement beneath the structure.

Except as specified, the procedures for placing and compacting the backfill shall be according to Articles 205.05 and 205.06. Except as described above, all backfill shall be placed in continuous horizontal layers not more than 200 mm (8 inches) in thickness, loose measurement, and each layer shall be compacted with a mechanical tamper of a type approved by the Engineer before the next layer is placed and the backfill shall be compacted to the density specified in Article 205.06. If the moisture content of the backfill material exceeds 110 percent of the optimum moisture content determined for this material, no additional material shall be placed without the permission of the Engineer.

A deposit of gravel or crushed stone, CA 5, 7, or 11, conforming to the gradation requirements of Article 1004.01, at least 600 mm (2 ft.) in each direction shall be placed at the back of each drain hole in abutments, wingwalls, retaining walls and culvert sidewalls. The bottom of this deposit shall be 50 mm (2 inches) below the drain hole. All form boards or other obstructions shall be removed from the drains before such deposit is placed. No additional compensation will be allowed for this work.

- **502.11 Disposal of Excess Excavation and Unsuitable Material.** Unsuitable material and suitable material in excess of that required for backfilling shall be disposed of by the Contractor according to Article 202.03.
- **502.12 Preservation of Channels.** The natural stream bed adjacent to the structure shall not be disturbed without permission from the Engineer. No excavated material shall be placed in stream channels without permission of the Engineer, and then only upon condition that final disposal of the material will be made in such manner that there will be no obstruction of the channels. If any excavation is made in stream channels outside the area to be excavated for the structure, the Contractor shall, at his/her expense, backfill all such excavations to the original ground surface or bed of stream with material satisfactory to the Engineer.

Within the limits of the right of way, excavated material, brush, logs and debris of any nature, shall be removed for the full length of the structure, so that the area will present a neat appearance and so that there will be no obstruction to the flow of the stream.

#### 502.13 Reserved.

### 502.14 Method of Measurement.

- (a) Contract Quantities. The requirements for the use of contract quantities shall conform to Article 202.07(a).
- (b) Measured Quantities. None of the excavation included within the volume limits of Channel Excavation or Earth Excavation will be included in the measurement of excavation for structures.

For Structure Excavation, Rock Excavation for Structures and Cofferdam Excavation, measurement for payment will be made in cubic meters (cubic yards) of the excavation actually performed within the limitations specified.

Structure Excavation will be measured in its original position. Horizontal dimensions will not extend beyond vertical planes 600 mm (2 ft.) outside of the edges of footings of bridges, walls and corrugated steel plate arches. The vertical dimension for Structure Excavation will be the average depth from the surface of the material to be excavated to the bottom of the footing or foundation seal as shown on the plans or ordered in writing by the Engineer.

Rock Excavation for Structures, other than boulders and masonry or timber, will be measured in its original position and the volume in cubic meters (cubic yards) computed by the method of average end areas.

Rock excavation for footings, foundation seals or other structures, except pipe structures, will be measured vertically from the top of the rock to the elevation of the bottom of the rock or bottom of the structure, whichever occurs first, and horizontally within the perimeter of the structure to be placed. Rock excavation for pipe structures will be measured vertically from the elevation of the top of the rock to the specified elevation below the bottom of the pipe and horizontally for the width of the trench specified for placing the pipe. When the depth of rock removal below the bottom of a pipe structure is not otherwise specified, the rock shall be removed to 200 mm (8 inches) below the bottom of the pipe; except for water service lines and pipe underdrains, the depth of removal shall be 75 mm (3 inches) below the bottom of the pipe. Rock excavation for storm sewers which are jacked in place will be measured as the volume actually moved, except that the horizontal dimension will not be greater than the external diameter of the pipe plus 300 mm (12 inches) and the vertical dimension will not be greater than the external diameter of the pipe plus 300 mm (12 inches) above the pipe and 200 mm (8 inches) below the pipe, unless the total vertical dimension is less than 1.2 m (4 ft.), in which case 1.2 m (4 ft.) may be used.

Where it is necessary to construct sumps in rock, measurements shall include the areas and depths required for such sumps. Boulders and

isolated rocks, 0.5 m³ (1/2 cu. yd.) or more in volume, will be measured individually and the volume computed from average dimensions taken in three directions. The quantity of masonry or timber to be paid for will be the volume of such material actually removed within the limits of the excavation as specified.

Cofferdam excavation, where specified, will be measured in cubic meters (cubic yards) in its original position within the cofferdam sheeting. The horizontal dimensions used in computing the volume will not extend beyond vertical planes 600 mm (2 ft.) outside of the edges of the pier footings or 1.2 m (4 ft.) outside of the faces of the pier wall whichever is greater. The vertical dimensions will be the average depth from the surface of the material to be excavated to the elevation shown on the plans for bottom of the footing or foundation seal, or as otherwise determined by the Engineer as the bottom of the excavation.

Excavation outside the maximum dimensions specified will not be measured for payment. The Contractor shall notify the Engineer a sufficient time in advance of starting excavation so that the necessary measurements can be made.

Excavation for the construction of slopewalls, pipe culverts, and concrete box culverts will not be measured for payment.

**502.15 Basis of Payment.** Except as provided, the work specified in this Section will not be paid for as a separate item. Where excavation for structures is not specified, the cost of the excavation shall be considered as included in the contract unit price for the class of concrete involved, or other unit price item of the work for which it is required.

Structure Excavation and Cofferdam Excavation, when specified, will be paid for at the contract unit price per cubic meter (cubic yard) for STRUCTURE EXCAVATION and COFFERDAM EXCAVATION.

When material classified as Rock Excavation for Structures is encountered and when the contract contains a unit price for Rock Excavation for Structures, the excavation of material classified as such, regardless of depth, will be paid for at the contract unit price per cubic meter (cubic yard) for ROCK EXCAVATION FOR STRUCTURES. When the contract does not contain a unit price for Rock Excavation for Structures, it will be paid for according to Article 109.04.

Where it is necessary to excavate below the plan bottom of footing elevation, the basis of payment shall be as follows:

For the first 75 mm (3 inches), the excavation will be paid for according to the contract unit prices for the type of excavation involved. The cost of furnishing and placing the crushed stone, gravel or other material, shall be included in the unit price bid for the class of concrete involved.

When it is necessary to excavate more than 75 mm (3 inches) below the plan bottom of footing elevation, the excavation will be paid for at the contract unit prices for the class of excavation involved. Furnishing and placing the crushed stone, gravel, or other material below the first 75 mm (3 inches) will be paid for according to Article 109.04.

Cofferdams, when specified, will be paid for at the contract unit price each for COFFERDAMS, at the locations specified. The size and details of the cofferdam shall meet the approval of the Engineer and no extra compensation will be allowed for a cofferdam of excessive size. Excavation from within a cofferdam added to the contract will be paid for at the unit price bid for cofferdam excavation, except if there is no item for Cofferdam Excavation in the contract, the excavation will be paid for according to Article 109.04.

When added to the contract by written permission of the Engineer, the cofferdams will be paid for according to Article 109.04. The excavation within the added cofferdam will be paid for at the contract price for Cofferdam Excavation. If a unit price is not provided in the contract, the excavation will be paid for according to Article 109.04.

Tree Removal and Protection of Existing Plant Material will be paid for according to Section 201.

When embankment construction is included in the contract, embankments constructed from surplus structure excavation will be paid for according to Section 205.





# **SECTION 503. CONCRETE STRUCTURES**

**503.01 Description.** This work shall consist of the construction of all cast-in-place concrete structures.

**503.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 - Materials:

	Item	Article/Section
(a) Por	rtland Cement Concrete (Note 1)	1020
(b) Pro	tective Coat	1023
(c) Pre	formed Expansion Joint Filler	1051.01 - 1051.09
(d) Wa	terproofing Material	1060.01 - 1060.08
	nmetallic Water Seals	
(f) Elas	stomeric Bearings	1083
(g) Pre	formed Elastomeric Compression Joint Seals for	Concrete 1053
(h) Ned	oprene Expansion Joint	1052
(i) Rei	inforcement Bars	508

Note 1. At the Contractor's option, Class SI Concrete may be used when Class MS Concrete is specified.

**503.03 Equipment.** Equipment shall meet the requirements of the following Articles of Section 1100 - Equipment:

	Item	Article/Section
(a)	Concrete Mixers	1103.01
(b)	Batching and Weighing Equipment	1103.02, 1103.03
(c)	Water Supply Equipment	1103.11
(d)	Hand Vibrator	1103.17(a)
		1103.17(g)

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(f)	Membrane Curing Equipment	1101.09(b
(g)	Finishing Machine	1103.13(a

## CONSTRUCTION REQUIREMENTS

**503.04 Excavation and Fill.** All excavation and backfill required for the construction of concrete structures shall be performed according to Section 502. Substructures, foundations and footings shall be constructed in open excavation wherever practicable.

**503.05 Falsework.** The Contractor shall submit detailed plans for falsework for examination by the Engineer. If such plans are not satisfactory to the Engineer, the Contractor shall make such changes in them as may be required, but it is understood that the Engineer's concurrence in the use of the plans as submitted or corrected shall in no way relieve the Contractor of responsibility for obtaining satisfactory results.

For continuous concrete slab and girder bridges, falsework and forms shall be provided for the full length of each continuous unit and the full width of the structure.

For calculating the strength of falsework, a mass (weight) of 2400 kg/m<sup>3</sup> (150 lbs. per cu. ft.) shall be assumed for the concrete. The design of the falsework shall take into account the weight of the concrete and also other loads incidental to the construction operations. All falsework shall be designed and constructed to provide the necessary rigidity and to support the imposed loads without appreciable settlement or deformation. The Contractor shall make allowance for the deflection of forms and for shrinkage and settlement of falsework, in addition to the allowance for the amount of dead load deflection and camber shown on the plans. A method satisfactory to the Engineer shall be used to detect any settlement that may occur during the placing of the concrete.

Falsework bents shall generally be founded upon piling driven to a capacity sufficient to support the load without appreciable settlement. If the soil is firm and well compacted, the Contractor may, as an alternate, place falsework bents upon concrete footing or mud sills of sufficient size that the pressure on the soil will not exceed 0.14 MPa (1 1/2 tons per sq. ft.) or the Contractor may support falsework from the piers or abutments, provided sleeves for any tie bolts can be cast into the concrete and the method proposed meets the approval of the Engineer. Sleeves or other appurtenances cast into the concrete shall be constructed so as to permit their removal to a depth of at least 40 mm (1 1/2 inches) from the face without injury to the concrete. Drilling into existing piers or abutments that are to remain as a part of the final structure will not be permitted for the support of falsework. The Engineer may require the Contractor to use screw jacks or hardwood wedges to take up any settlement in the form work, either before or during the placing of the concrete.

Falsework supporting cast-in-place concrete, and forms supporting concrete floor slabs on beams shall remain in place until tests show that the concrete has attained a flexural strength of 4.5 MPa (650 psi) and also until at least 7 days have elapsed from the time pouring is completed on the span or series of continuous spans. If high-early-strength portland cement is used, this period may be reduced as directed by the Engineer. In the absence of tests to determine the flexural strength, the falsework shall remain in place until at least 14 days have elapsed after the placing of the concrete, exclusive of days in which the temperature falls below 7 °C (45 °F.).

The Contractor shall leave falsework in place for a longer period of time when required by the Engineer. No superimposed load, either dead or live, will be allowed upon the bridge during the period the falsework is required to remain in place. The falsework shall not be removed from any span of a cast-in place continuous unit until the concrete in the entire unit has been cured for the required period of time. If longitudinal expansion joints are provided in the roadway of any superstructure, the falsework shall not be released under one portion adjacent to such a joint until the concrete in that portion has attained the required strength and the concrete has been placed in the portion on the opposite side of such joint. The falsework shall not be removed from the portion on either side of such joint until all the concrete has set sufficiently to avoid damage to the concrete adjacent to the joint.

Falsework shall be removed in such a manner as to permit the concrete to take uniformly and gradually the stress due to its mass (weight).

**503.06 Forms.** For continuous concrete slab and girder bridges, forms shall be provided for the full length and width of each continuous unit formed. The Contractor shall, when required, submit detailed plans for forms for review and approval by the Engineer.

A mass of 2400 kg/m³ (weight of 150 lbs./ft³) shall be assumed for the concrete in the design of the forms. The design of the forms shall provide for accommodation of incidental loads, settlement, deadload deflection, shrinkage, and deformation of the form components. The forms shall provide the structural capacity required to produce finished concrete to the lines and grades specified on the plans. Forms shall be constructed of wood, metal, or other material approved by the Engineer.

Wood forms for exposed surfaces shall be made of dressed lumber or plywood, with or without a form liner of a type approved by the Engineer. Except for curved and special surfaces, wood forms shall be surfaced on both sides and both edges and shall be sized to uniform thickness.

Metal forms shall be of such thickness that they will remain true to shape. All bolts and rivet heads in contact with concrete shall be countersunk. Clamps, pins and other connecting devices shall be designed to hold the forms rigidly in place and to allow removal without injury to the concrete. Metal forms which do not present a smooth surface or line up properly shall not be used. Special care shall be exercised to keep metal forms free from rust, grease or other foreign matter which would discolor the concrete.

Forms shall be filleted at all sharp corners. Triangular moldings used for fillets or V-shaped notches shall have 2 equal sides. Where the size of the molding is specified, the dimension stated shall be the width of each of the equal sides.

Moldings for fillets and notches shall be 20 mm (3/4 inch). The moldings for corners on handrails and handrail posts shall be 15 mm (1/2 inch). All moldings shall be cut with true edges, surfaced on all sides, and not warped, cracked or frayed. Forms shall be given a bevel or draft in case of all projections, such as girders and copings, to assure easy removal.

When directed by the Engineer, temporary openings shall be provided in the bottom of forms for cleaning out all extraneous material immediately prior to placing concrete.

Tie rods, bolts and anchorages, within the forms shall be constructed so as to

permit their removal to a depth of at least 40 mm (1 1/2 inches) from the face without injury to the concrete. Wire ties, when used, shall be cut back at least 15 mm (1/2 inch) from the face of the concrete upon removal of the forms, except on surfaces not exposed to view, they may be cut flush. All fittings for metal ties shall be of such design that, upon their removal, the cavities which are left will be of the smallest practicable size.

Forms shall be set and maintained to the lines and grades specified on the plans and in a manner approved by the Engineer until their removal. Prior to each reuse, forms shall be refurbished to the extent deemed necessary by the Engineer. The Engineer will be the sole judge as to the acceptability of forms for reuse.

Prior to bar placement, forms shall be coated with form oil or other bond breaking agent approved by the Engineer. In lieu of form oil, wood forms may be saturated with water immediately prior to placement of the concrete, when the surfaces are not exposed to view.

Forms shall remain in place until permission is obtained from the Engineer for their removal. The method of form removal shall not result in damage to the concrete. If forms are removed prior to the completion of the required curing period, curing shall be resumed with an approved curing method for the remainder of the curing period. Forms shall not be removed from the bottom of slabs, beams, or floors until a flexural strength of 4.5 MPa (650 psi) has been obtained. In the absence of tests to determine the flexural strength, the forms shall remain in place until at least 14 days have elapsed after placing the concrete, exclusive of days the temperature falls below 7 °C (45 °F).

Forms used in casting concrete bridge floors will not be allowed to remain in place. All tie rods, bolts, anchorages, brackets and other forming hardware which is incorporated into the bridge deck shall be either epoxy coated or galvanized. Areas of epoxy coating which have been damaged due to welding shall be repaired.

If the Contractor intends to use cantilever forming brackets on the exterior beams or girders, the following procedures will be required to prevent beam twisting:

- (a) The resulting force of the leg brace of the cantilever bracket shall bear on the web and within 150 mm (6 inches) of the bottom flange of the beam or girder.
- (b) The exterior beams or girders, supporting cantilever forming brackets, shall be tied together at 1.2 m to 2.4 m (4-ft. to 8-ft.) intervals. On stage construction, where cantilever brackets are supported on one exterior line of beams or girders, this line shall be tied to the furthest opposite interior line. Ties shall be a minimum No. 15 (No. 4) epoxy coated reinforcement bars with threaded ends. Each tie bar shall be furnished with an approved tie bar stabilizing system consisting of adjustable end clips, lag studs, and turnbuckles. The tie clips shall mechanically attach to the outside fascia girder or interior girders as required for stage construction and the individual tie bar. The tie bars, turnbuckles, lag studs, and tie clips shall be furnished by the Contractor. The tie bars shall be placed parallel to and have the same clearance from the deck form work as required for the bottom transverse reinforcement. No welding will be permitted to the structural steel or stud shear connectors for the installation of the tie bar stabilizing system. After installation, the tie bar shall be tensioned with the turnbuckles until the bar does not vary from a straight line from center of end clip to

center of opposite end clip.

- (1) If finishing machine rails are on the outside of the water table, the tie spacing shall not be greater than 1.2 m (4 ft.) centers.
- (2) If finishing machine rails are on the top flange of the exterior beam, the tie spacing shall not be greater than 2.4-m (8-ft.) centers.
- (3) Precast, prestressed concrete beams shall have ties not greater than 2.4-m (8-ft.) centers regardless of where the finishing machine rails are placed.
- (4) Cross frames on steel girders which do not have a top strut shall not be considered a tie.
- (c) Hardwood 100 mm x 100 mm (4 inch x 4 inch) blocks or material of an equivalent strength shall be wedged between webs of exterior and first interior beams within 150 mm (6 inches) of the bottom flanges at each location where the top of the beams are tied together.

This additional work for using the cantilever brackets will not be paid for separately as the Contractor has other options available to form the outside of the deck without using cantilevered hangers on the exterior beams. If the Contractor elects to use cantilever brackets without following the above required procedure, the Contractor shall submit detailed plans for approval by the Engineer according to the first paragraph of this Article.

**503.07** Placing and Consolidating. No concrete shall be placed on ice, snow or frozen foundation material. The Contractor shall be responsible for all concrete damaged by low temperatures and shall remove and replace any concrete so damaged at his/her expense.

The method and manner of placing concrete shall be such as to avoid segregation or separation of the aggregates or the displacement of the reinforcement.

Open troughs and chutes shall extend as nearly as practicable to the point of deposit. Dropping the concrete a distance of more than 1.5 m (5 ft.) or depositing a large quantity at any point and running or working it along the forms will not be permitted. The concrete for walls with an average thickness of 300 mm (12 inches) or less shall be placed with tubes so that the drop is not greater than 1.5 m (5 ft.).

When concrete is conveyed by mechanically applied pressure, the equipment shall be suitable in kind and adequate in capacity for the work, and arranged so that vibrations will not damage freshly placed concrete. Aluminum pipe or conduit will not be permitted in conveying or placing concrete. Mixed concrete shall be supplied so that the pumping equipment will be in continuous operation.

Placing of concrete shall be regulated so that the pressures caused by the wet concrete will not exceed those used in the design of the forms. Special care shall be taken to fill each part of the forms by depositing the concrete as near its final position as possible, to work the coarser aggregates back from the face and to force the concrete under and around the reinforcement bars without displacing them. After the concrete has taken its initial set, care shall be exercised to avoid jarring the forms or placing any strain on the ends of projecting reinforcement.

The concrete in all structures, and in all other concrete construction exclusive of

pavement, shall be consolidated by internal vibration. A vibrator will be required except in thin sections or inaccessible locations where consolidation by internal vibration is not practicable.

The Contractor shall provide and use a sufficient number of vibrators to ensure that consolidation can be started immediately after the concrete has been deposited in the forms.

The vibrators shall be applied to the concrete immediately after it is deposited and shall be moved throughout the mass so as to thoroughly work the concrete around the reinforcement and embedded fixtures and into the corners and angles of the forms. Vibrators shall not be attached or applied to the forms, reinforcement bars, or the surface of the concrete.

The vibration shall be of sufficient duration and intensity to thoroughly consolidate the concrete into place, but shall not be continued so as to cause segregation. Application of vibrators shall be at points uniformly spaced and not farther apart than twice the radius over which the vibration is visibly effective. Vibration shall be supplemented by spading when required by the Engineer as is necessary along form surfaces and in corners and locations impossible to reach with the vibrators. In addition to the internal vibration required herein, formed surfaces which will be exposed to view after completion of the work shall be spaded with a spading tool approved by the Engineer, to prevent the formation of voids in the surface.

The provisions of this Article shall also apply to precast piling, concrete cribbing, and other precast members, except as otherwise specified in Article 504.06(c)(4) for precast, prestressed concrete members. If approved by the Engineer, the manufacturer's methods of vibration may be used.

Concrete shall be placed in continuous horizontal layers. When it is necessary by reason of an emergency to place less than a complete horizontal layer in one operation, such layer shall terminate in a vertical bulkhead. In order that the concrete will not be injured and that there shall be no line of separation between the batches, the separate batches shall follow each other closely, and in no case shall the interval of time between the placing of successive batches be greater than 20 minutes. If ready-mixed concrete is used, the requirements of Article 1020.11 shall apply. Delivery of mixed concrete shall be regulated so that there will not be an interruption of more than 20 minutes duration in the placing of concrete in the forms.

The operations of depositing and consolidating shall be conducted so that the concrete after removal of the forms will be reasonably free from aggregate pockets and honeycomb. All exposed surfaces shall be smooth and dense. All unexposed surfaces shall be dense and free from excessive depressions or projections. All concrete which does not meet these requirements shall be removed and replaced by the Contractor or shall be repaired to the satisfaction of the Engineer.

**503.08 Depositing Concrete Under Water.** Concrete shall not be exposed to the action of water before setting, or deposited in water, except with the approval of the Engineer and under his/her immediate supervision.

When concrete is deposited under water, it shall be carefully placed in its final position by means of a tremie and shall not be disturbed after being deposited. Special care shall be exercised to maintain still water at the point of deposit. No concrete shall be placed in running water and all form work designed to retain concrete under water shall be watertight. The consistency of the concrete shall be

carefully regulated and special care shall be exercised to prevent segregation of the materials. The method of depositing concrete shall be regulated so as to produce approximately horizontal surfaces.

The tremie shall consist of a tube having a diameter of not less than 250 mm (10 inches) and constructed in sections having flanged couplings fitted with gaskets. The means of supporting the tremie shall be such as to permit the free movement of the discharge end over the entire top surface of the work and shall be such as to permit it to be rapidly lowered when necessary to choke off or retard the flow. The discharge end shall be entirely sealed at all times and the tremie tube kept full to the bottom of the hopper. When a batch is dumped into the hopper, the tremie shall be raised slightly to induce the flow of concrete but the lower end shall be kept below the top of the deposited concrete until the batch is discharged. The flow shall then be stopped by lowering the tremie. The flow shall be continuous and in no case shall it be interrupted until the work is complete.

At the Contractor's option, pumping equipment may be used in lieu of a tremie to deposit concrete under water. The Engineer will approve the concrete pumping equipment and its piping before the work is started.



**503.09 Construction Joints.** Construction joints shall be made only at locations shown on the plans or approved by the Engineer, except in cases of breakdowns or other unforeseen and unavoidable delays in which case the Engineer will designate if the joint is to be bonded or unbonded.

Construction joints shown on the plans shall be unbonded. When not shown on the plans, their location shall be confined, as far as possible, to regions of low shearing stress and to locations that will be hidden from view. Insofar as possible, the location of construction joints shall be planned in advance and the concrete placed continuously from joint to joint. The reinforcing steel shall extend through such joints. If a construction joint is necessary in the sloped portion of a wingwall or similar location where a featheredge would result, the joint shall be constructed so as to produce an edge thickness of not less than 150 mm (6 inches) in the succeeding layer. No construction joint shall be placed within 450 mm (18 inches) of the top of any wall or pier unless the details of the work provide for a coping having a thickness of less than 450 mm (18 inches), in which case, at the option of the Engineer, a construction joint may be made at the under side of the coping.

The face edges of all joints which are exposed to view shall be carefully finished true to line and elevation. Shear keys, formed into or out from the surface of the previously placed concrete, or steel dowels, shall be used where required. Shear keys formed into the concrete shall be formed by the insertion and subsequent removal of beveled wood strips which shall be thoroughly saturated with water prior to insertion. Steel dowels may, at the discretion of the Engineer, be used in lieu of keys. The size and spacing of the keys and dowels will be as determined by the Engineer.

Between adjacent sections of retaining walls and abutment walls, a V-shaped groove shall be formed in the exposed face of the walls by the use of 15 mm (1/2 inch) triangular molding on each side of the joint.

Care shall be exercised not to injure the concrete or break the concrete-steel bond at any time. In constructing bridge floors where longitudinal joints are specified, a platform shall be constructed outside the longitudinal joints and supported on the lower slab form, and personnel will not be permitted to stand or walk on the projecting reinforcement bars until the concrete has hardened.

- (a) Bonded Construction Joints. Except where otherwise specified, bonded construction joints, where required, shall be made using any of the following procedures:
  - (1) After the concrete has hardened so that the header board or form can be removed without damage to the concrete, it shall be removed and the cement paste removed from the surface by washing with water under pressure or by sandblasting to expose clean, well bonded aggregate.

To facilitate the removal of the cement paste, the surface of the header board or form that will be in contact with the first pour may be thoroughly covered with a retarder. The retarder shall be a ready-to-use liquid compound that delays the set of the surface concrete to facilitate the exposure of the aggregate and shall be approved by the Engineer in advance of the beginning of the work. It shall produce results satisfactory to the Engineer and will be evaluated on the basis of tests performed by the Engineer, and on the basis of the manufacturer's data and recommendations. When the retarder is used, washing with water under pressure shall be used to expose clean, well bonded aggregate.

After the surface has been prepared, the concrete shall be kept saturated with water until the new concrete is placed, or it shall be saturated for a period of 4 hours before placing the new concrete. Immediately prior to the placing of new concrete, the forms shall be drawn tight against the concrete already in place and the surface shall be covered with a thin coat of mortar composed of 1 part portland cement and 2 parts of sand.

(2) After the header board or form is removed and the concrete has cured for the normal period, the second pour shall be bonded to the first pour by the application of a two-component liquid polysulfide polymer epoxy resin concrete adhesive to the concrete joint surface. The epoxy concrete adhesive shall conform to the requirements of Section 1025.

The surface on which the adhesive is to be applied shall be free of oil, dirt and loose concrete. All unsound concrete should be removed until a base of strong, undamaged concrete is exposed on which to apply the adhesive. Heavy deposits of dirt or oil products shall be removed by wire brushing or sandblasting. The surface shall be free of moisture and dry before application of the adhesive. The adhesive shall not be applied to newly placed concrete before the normal curing period has elapsed.

Immediately before application, the 2 adhesive components shall be combined in the proportions specified by the adhesive manufacturer. The components shall be intimately blended by hand or with a slow speed motor drive mixing device. The mixture of adhesive shall next be thinned by adding and blending the solvent into the adhesive. The amount of adhesive mixed at one time shall be limited to that quantity

which can be conveniently applied within the pot life of the adhesive.

The two-components and solvent shall not be mixed more than 30 minutes prior to use. The resulting adhesive shall be brushed onto the concrete in a layer 125  $\mu m$  to 250  $\mu m$  (5 to 10 mils.) thick or an average coverage of 2.5 to 5.0 m²/L (100 to 200 sq. ft. per gal.). After the adhesive has been applied, concrete shall not be placed against it until the solvent has evaporated. This period shall be between 30 to 60 minutes depending on weather conditions. The adhesive must be tacky and not dry at the time of concrete application. Areas which have been allowed to become dry shall be recoated before concrete is placed.

Because of toxicity of the materials, including the solvents, some safety and health hazards exist in the handling and use of the materials, and may cause serious rash in persons sensitive to the materials. Further, in the use of solvents as cleaning aids, there exists a fire and flash hazard. The Contractor shall obtain from the formulator of the materials complete instructions as to the safety, health and handling precautions that must be exercised with respect to the materials to be used, and as to the procedure that should be followed in the event that personnel come in contact with the material. Before they are permitted to proceed with the work, the personnel shall be instructed as to the hazards to which they will be exposed, the necessary safety precautions and the procedure to be followed in the event of accidental contact with the materials.

(b) Construction Joints in Bridge Floors. Longitudinal and transverse construction joints specified for bridge floors shall be constructed as specified in Article 503.09(a)(2).

Horizontal construction joints, when specified between the top of the bridge floor and the curbs or parapets, shall be constructed as specified in Article 503.09(a).

The Contractor, subject to approval of the Engineer, may pour a bridge floor full width with horizontal bonded construction joints between the floor and curbs or parapets. The omission of longitudinal bonded joints will not be permitted if the Contractor does not have the necessary equipment or capacity for a satisfactory job.

- (c) Unbonded Construction Joints. Unbonded construction joints shall be made by forming or striking off the previously placed concrete to a true and even surface and allowing it to set. After the concrete has set, the new concrete shall be placed in contact with it and thoroughly consolidated to secure a close contact between the old and new concrete at all points, with no attempt to secure a bonding of the new to the old work.
- **503.10 Expansion Joints.** Expansion joints shall be constructed as specified so as to permit freedom of movement. After all other work is completed, all thin shells of mortar and projections of the concrete into and around the joint space that are likely to spall under movement or prevent the proper operation of the joint shall be carefully removed.

- (a) Open Joints. Reinforcement shall not extend across or into an open joint. Open joints in railings or under projecting portions of rail posts shall be formed with square corners unless beveled corners are specified. When not protected by metal expansion guards, open joints in floors and sidewalks shall be finished with an edging tool satisfactory to the Engineer.
- (b) Filled Joints. When preformed joint filler is specified, the material may be any one of the types specified in Section 1051. The preformed joint filler shall be placed in correct position before the adjacent concrete on one side of the joint is poured. The joint filler shall be cut from the least practicable number of pieces to fit exactly and completely fill the space shown on the plans. Loose fitting or open points between sections of filler or between filler and forms will not be permitted.
- (c) Expansion Guards. The plates, angles or other structural shapes provided as expansion guards at joints between adjacent spans shall be accurately fabricated at the shop to conform to the section of the concrete floor or sidewalk. The fabrication shall conform to Section 505 and the painting shall conform to Section 506. Expansion guards shall be held securely in correct position during the placing of the concrete. The joint opening shall be adjusted according to the temperature at the time of placing so that the specified opening will be secured at a temperature of 10 °C (50 °F.). The opening for each 10 m (100 ft.) of bridge between the nearest fixed bearings each way from the joint shall be reduced 1 mm (1/8 inch) from the amount specified, for each 8 °C (15 °F.) the temperature at the time of placing exceeds 10 °C (50 °F.) and increased 1 mm (1/8 inch) from the amount specified, for each 8 °C (15 °F.) the temperature at the time of placing is below 10 °C (50 °F.).
- Preformed elastomeric compression joint seals, when (d) Sealed Joints. specified, shall be of the size and shape shown on the plans. The seals shall be installed by suitable hand or machine tools and thoroughly secured in place with the approved adhesive which shall cover both sides of the seals over the full area in contact with the sides of the joint. The adhesive may be applied to the sides of the joint or the seals or both. The seals shall be installed in a compressed condition and shall at all times be below the level of the deck surface as shown on the plans. The seals shall be in one continuous piece for the full length of the joint. The continuous piece for installation shall not have more than one manufacturer's butt splice within its length. If the splice is torn or damaged it shall be repaired, prior to installation. using the manufacturer's recommended Temperature limitations of the adhesive, as specified by the manufacturer, shall be observed. Joints shall be clean and free of foreign material immediately prior to installation of the seals.

Neoprene expansion joint seals shall conform to the details shown on the plans and as specified. The Contractor shall obtain installation instructions from the supplier of the expansion joint material and comply with the procedures specified in the installation of the joint. The Contractor shall form the concrete blockouts, set anchor bolts or studs, apply sealants and adhesives, and install joint units as shown on the approved shop drawings. Prior to placement of the deck concrete, the Contractor shall have written approval of joint details, concrete blockouts, anchor bolt placement, the seat conditions and the cleanout of the joint opening. The shop drawings, along

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with joint details, shall include details of the concrete blockout if required for the installation, a layout plan of the joint units to be used, and the spacing and location of the anchor bolts or studs. Details of installation shall meet with the approval of the Engineer.

Anchor bolts shall be set in their proper location by the use of a suitable template and shall be cast-in-place except as otherwise shown or specified. All loose, long, or misaligned anchor bolts shall be corrected in a manner approved by the Engineer. Concrete inserts will not be permitted as a substitute for cast-in-place or epoxy-grouted anchor bolts. When neoprene expansion joint pads are to be seated on structural steel joint elements, automatically end welded threaded studs, as shown on the plans, shall be used.

All forms and debris shall be removed from the joint opening. Concrete or metal surfaces on which the neoprene expansion joints are to be set shall be dry; clean and free from dirt, grease, loose concrete, and contaminants; level; and sound with no broken or spalled concrete. Adjacent joint seats shall be on a straight plane with each other. Joint seals shall not be placed until the Engineer has checked the seats with a straightedge and approved the alignment. Misalignments shall be corrected by grinding or other approved procedures, including, if necessary, concrete removal and replacement to obtain proper alignment. Joint opening and blockout will be approved for conformance to plan dimensions prior to placement of joint seals.



The neoprene molded sealing element shall be furnished and installed in one continuous, unbroken length for the entire roadway joint length. The molded flap for use at the curbs, parapets and walls shall be trimmed as required to fit roadway blockouts and installed in adhesive/sealant bedding compound as shown on the plans. The continuous roadway seal shall then be set in the adhesive/sealant over the molded flap piece and across the The adhesive/sealant must be liberally applied over the entire blockout or metal seat area as the sealing element is set into it. The anchor blocks shall then be set in position over the seal with the nuts torqued to at least 90 N m (65 ft. lbs.). A minimum of 24 hours after initial installation, the nuts shall be retorqued to the initial (65 ft. lbs.). Prior to filling the space in the bolt wells, the Engineer's inspection of the anchor fasteners and tightening of the units will be required. Any wells sealed without the Engineer's approval shall be opened and redone at the Contractor's expense. Full-length anchor block's units, with tongue and groove or other positive type interconnects, are required, except as otherwise shown on the approved shop drawings. All joints between units, around connecting bolts, and cavity plugs shall be carefully sealed with a block flexibilized epoxy sealant in a neat workmanlike manner to seal out water and protect against corrosion. Neoprene surfaces to be in contact with adhesive or sealant shall be cleaned with an acceptable solvent as recommended by the manufacturer or wire brush prior to installation to provide a bonding surface for the adhesive or sealant.

Where longitudinal joints intersect with transverse joint seals, a positive seal shall be provided by flattening and extending the longitudinal joint neoprene seal element under the transverse joint pad. When this procedure is not

practical, a separate neoprene apron, bonded to the longitudinal seal element, may be used.

The finished joint shall present a smooth, neat appearance with no protruding bolts or rough joints. Excess sealant shall be wiped or scraped away before it becomes hard. Upon completion of an entire joint, the Contractor shall grind any uneven end butt connections flush. Any openings between butt ends not showing sealant to the top shall be cleaned and filled with sealant. Where the joint pads are inset into the concrete blockouts, the edges between the concrete and the pads shall be sealed with sealant. When the bridge deck is to be waterproofed and surfaced, the installation of the joint shall be completed prior to placement of the deck waterproofing and bituminous concrete surfacing.

**503.11 Anchor Bolts and Bearings.** Anchor bolts shall conform to Article 505.04(u). Metal bearings shall be fabricated according to Article 505.04(l). Anchor bolts and bearings shall be set according to Article 505.08(f). When bed plates are set in portland cement mortar, no superstructure or other load shall be placed thereon until this mortar has been allowed to set for a period of at least 96 hours, with adequate provision being made to keep it well moistened during this period.

Elastomeric bearings shall be furnished in assemblies and installed as shown on the plans and shall be packaged, crated or wrapped in such a manner so that the elastomeric bearing assembly will not be damaged during handling, transporting or shipping. Any bearing damaged during handling, transporting, shipping or installing shall be replaced by the Contractor at his/her own expense. Unless otherwise approved by the Engineer, the elastomeric bearing assemblies shall be furnished as a complete unit from one manufacturing source. Exposed edges and other portions of the structural steel bearing plates shall be painted according to Article 506.05. During cleaning and painting, the stainless steel and TFE sheet sliding surfaces and the elastomer shall be protected from abrasion and paint.

**503.12 Drainage Openings.** Drain holes, 75 mm (3 inches) in diameter, spaced approximately 2.4 m (8 ft.) apart horizontally and 1.8 m (6 ft.) apart vertically, shall be constructed in abutment walls, wingwalls, retaining walls, and culvert sidewalls. A cubical deposit of gravel or broken stone shall be placed behind each drain hole according to Article 502.10. The lower line of drain holes shall be 600 mm (2 ft.) above the flow line or grade line.

The locations of roadway drains on all concrete superstructures or floors shall be adjusted so as to prevent the discharge of drainage water against any portion of the structure, or directly onto any railroad, highway or unprotected embankment beneath the structure.

Drains consisting only of openings formed in the floor and curbs shall be provided with a surrounding drip notch in the bottom surface of the slab as provided in Article 503.06.

Metal floor drains shall be as specified and shall be placed and securely fastened in position before the concrete is placed.

**503.13 Nonmetallic Water Seals.** Nonmetallic water seals shall be installed as specified. Provisions shall be made to adequately support the water seal during construction. The projecting edges and ends of partially embedded water seals shall

be protected from damage.

When splices are required, they shall be made by heating or vulcanizing to form continuous watertight joints. For the polyvinylchloride water seal, the heat shall be sufficient to melt but not char the plastic.

**503.14 Foundations and Footings.** All footings shall be as specified except that the Engineer may order, in writing, such changes in the footings as may be necessary to secure a satisfactory foundation.

Piling may be added or deleted from footings of substructures when the natural foundation conditions encountered make it necessary. The footings will be redesigned, when necessary, to permit the addition of piles or to spread the footing for stable bearing.

The final decision as to the elevation at which footings shall be placed and as to the requirements for piling will be made by the Engineer as the excavation progresses or after a test pile has been driven.

When concrete footings are constructed in excavation other than rock, forms shall be provided for all vertical surfaces, except when the foundation material may be excavated accurately to the lines and grades required and will remain true to such lines and grades until the concrete is placed in the excavated space, the Engineer may permit forms to be omitted. When forms are omitted, the entire excavated space shall be filled with concrete to the elevation of the top of the footing. Where concrete footings are to be constructed in rock excavation, forms shall be omitted and the entire space, excavated in rock according to Article 502.05, shall be filled with concrete up to the top of the footing, or to the top of the rock if the latter is lower. In all cases, where sumps are required for the disposal of water, they shall be constructed outside the footing areas and forms shall be used for the footings at each sump. When footings are placed without forms, the additional concrete required to fill any irregularities or other excavated space outside the specified lines of the footings shall be placed at the entire expense of the Contractor.

Except for joints specified, the concrete footing for each substructure unit shall be placed as a monolith. Vertical construction and expansion joints shown on the plans in abutments and wing walls shall not extend through the footing. In retaining walls or other structures, where joints extend through the footing, the water seal required in the joints between adjacent sections of wall need not extend below the top of the footing.

Footings shall be allowed to set for a period of time which is sufficient to preclude the possibility of damage by subsequent work.

If it is necessary to increase or decrease the depth of the foundations from that shown on the plans, the thickness of the wall where it joins the footing shall be increased or decreased the same amount per meter (foot) as the main wall increases per meter (foot) of its height as shown on the plans.

If the total height of the wall is changed by more than 600 mm (2 ft.) from that shown on the plans, the wall and footing will be redesigned.

**503.15 Foundation Seals in Cofferdams.** When conditions are encountered which render it impractical to dewater a cofferdam before placing concrete, the Contractor will be permitted to construct a concrete foundation seal of such

dimensions as may be necessary. Foundation seals will be paid for only when called for by the plans or authorized in writing by the Engineer. Their use will not be authorized except where properly constructed cofferdams cannot be dewatered satisfactorily by ordinary means.



The foundation seal shall be constructed below the elevation of the footing as shown on the plans, and will not be considered a part of the footing. Foundation seals shall be designed to withstand the hydrostatic pressure, taking into account the resistance afforded by the cofferdam and foundation piles. Foundation seals shall be constructed of Class SC Concrete according to Section 1020. The concrete in each foundation seal shall be placed in one continuous operation and according to Article 503.07.

The foundation seal shall not be omitted without written consent of the Engineer. Such consent will in no way relieve the Contractor of any responsibility for the safe construction of the foundation, or for any damage done as a result of the omission of the foundation seal.

**503.16 Surface Finish.** The external surface of all concrete shall be thoroughly worked during the operations of placing in such a manner as to work the mortar against the forms to produce a smooth finish free of honeycomb and with a minimum of water and air pockets.

Depressions resulting from the removal of ties, and holes left by attachments to rod or bolt anchorages shall be carefully and neatly pointed with a mortar of sand and cement mixed in the proportions used in the concrete being treated.

Air pockets or rough places larger than 15 mm (1/2-inch) diameter occurring in any surface shall be pointed as specified in the foregoing paragraph. Honeycombed areas shall be chipped out by the Contractor and inspected by the Engineer before being pointed. Pointed areas mentioned in this paragraph shall then be given a normal finish.

(a) Normal Finish. All surfaces that will be exposed to view after completion of the work, except surfaces specified in Article 503.17(c) and (d), shall be given a normal finish. This shall consist of the removal of fins, rough spots, stains, hardened mortar or grout, and form lines by rubbing with a No. 16 carborundum stone or an abrasive of equal quality without materially changing the texture of the surface. The rubbing shall be continued sufficiently to remove all roughness and projections.

When the surface of concrete that will be exposed to view shows a film of oil left from an excess of oil on the forms, or the concrete is oil-stained, or is otherwise not of uniform color, the Engineer may require the Contractor to employ the following cleaning method. Mix 1 part portland cement and 1 1/2 parts fine sand with sufficient water to produce a grout having the consistency of thick paint. Portland cement from the source of the cement used in the concrete shall be used in the grout. Wet the surface of the concrete sufficiently to prevent absorption of water from the grout and apply the grout uniformly with brushes, completely filling air bubbles and holes. Immediately after applying the grout, float the surface with a suitable float, scouring the wall vigorously. While the grout is still plastic, the surface shall be finished with a sponge rubber float removing all excess grout. This finishing shall be done at the time when grout will not be pulled from holes

or depressions. Next, allow the surface to dry thoroughly, then rub it vigorously with dry burlap to completely remove any dried grout. There shall be no visible film of grout remaining after this rubbing. The entire cleaning operation for any area must be completed the day it is started. No grout shall be left on the wall overnight. No cleaning operations shall be undertaken until all patching and filling of tie holes has been done.

(b) Rubbed Finish. When specified, a rubbed finish shall be provided. Surfaces to be rubbed shall be designated on the plans or in the Special Provisions.

Surfaces requiring a rubbed finish shall be thoroughly wet with a brush and rubbed with a No. 16 Carborundum stone, or an abrasive of equal quality, bringing the surface to a paste. The rubbing shall be continued sufficiently to remove all roughness and projections, producing a smooth dense surface free from pits and irregularities. The material which has been ground to a paste in the above process shall be carefully spread or brushed uniformly over the rubbed surface and permitted to reset. The final finish shall be obtained by a thorough rubbing with a No. 30 Carborundum stone, or an abrasive of equal quality, first wetting with a brush as for the initial rubbing. The finish rubbing shall continue until the entire surface is of a smooth texture and uniform in color.

- (c) Bearing Seats. Seats for bridge bearings shall be finished smooth at the proper plane and elevation with a steel trowel. After the water sheen has disappeared, the surface shall be given a final finish by brushing with a whitewash brush. The brush shall be drawn across the seat longitudinally with the bridge deck, with adjacent strokes slightly overlapping, producing a uniform, slightly roughened surface with parallel brush marks.
- **503.17 Concrete Superstructures.** The concrete in any cast-in-place superstructure or floor shall be placed in one continuous operation between expansion or construction joints specified. Standby equipment of sufficient capacity shall be available so that there will be no delay in placing of the concrete once the operation has started. Sidewalks, curbs or medians shall be placed monolithically with the floor or superstructure unless a construction joint between them is specified.
  - (a) Concrete Floors on Steel or Precast Concrete Superstructures. Before concrete floors are placed on a previously erected superstructure, all falsework supporting the superstructure members shall have been removed. Concrete floors shall be constructed so that, after taking into account any anticipated deflection of the supporting members due to the weight of the floor as shown by the deflection diagram on the plans, the top of the finished floor shall be at the specified elevation.

Where necessary, a concrete fillet between the underside of the floor slab and supporting member shall be provided. The height of this fillet shall include allowance for dead load deflection.

(b) Cast-in-place Concrete Superstructures. Concrete parapets and railings, and those concrete curbs, sidewalks, and medians not placed monolithically with the superstructure, shall not be placed until after the superstructure has been completed and the falsework removed.

- (c) Bridge Floors. Cast-in-place concrete bridge floors shall be finished and textured in the following manner:
  - (1) Floors 30 m (100 ft.) or more in length.
    - Finishing. After the concrete is placed and consolidated, it shall be struck off and finished with a power driven finishing machine.

The finishing machine will not be required for that portion of the floor outside of the outer construction joints shown on the plans, when the distance from the construction joint to the parapet flow line is less than 2 m (6 ft.).

Long handled floats having blades not less than 1 m (3 ft.) in length and 150 mm (6 inch) in width may be used to smooth and fill occasional porous or open-textured areas in the floor surface, but shall not be used to float the entire surface. The Contractor shall take immediate corrective action to eliminate the causes of the porous or open-textured areas as they occur.

The Contractor may, at his/her option, transversely float the entire floor surface with a hand-operated float having blades not less than 3 m (10 ft.) in length and 150 mm (6 inch) in width.

Unusual jobsite conditions which occur during the floor placement and may require finishing or floating techniques not specified above shall be approved by the Engineer.

Water will not be permitted to be applied to the floor surface unless it can be demonstrated to the Engineer that workability cannot be obtained. If water is permitted by the Engineer, it shall be applied in a fine mist by means of a sprayer, at a distance not to exceed 300 mm (12 inch) from the surface. Application by brushes or any other method that concentrates water will not be permitted.

Surface Test. After the finishing has been completed and while b. the concrete is still plastic, the surface of the concrete shall be tested for trueness with a 3 m (10 ft.) straightedge. Contractor shall furnish and use an accurate 3m (10 ft.) straightedge which has a handle not less than 1 m (3 ft.) longer than 1/2 the width of the floor. The straightedge shall be held in contact with the surface and passed gradually from one side of the floor to the other. Advance along the floor shall be in successive stages of not more than 1/2 the length of the straightedge. Any depressions found shall be immediately filled with freshly mixed concrete, struck off, consolidated and refinished. High areas shall be cut down and refinished. The straightedge may be used to finish and seal the floor surface when approved by the Engineer. Special attention shall be given to assure that the finished profile of the surface across joints meets the requirements for smoothness. Straightedge testing of the floor shall continue until the entire surface is found to be free from variations from the straightedge, and the floor conforms to

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the required grade and cross-section.

If the Contractor chose to transversely float the entire floor surface with the 3 m (10 ft.) hand float and surface corrections made, additional straightedge testing will not be required.

- (2) Floors under 30 m (100 ft.) in length.
  - a. Finishing. After the concrete is placed and consolidated, it shall be struck off with a vibrating screed allowing for camber, if required. The vibrating screed shall be of a type approved by the Engineer. A slight excess of concrete shall be kept in front of the cutting edge at all times during the striking off operation.

The floor surface shall be finished with long handled floats having blades not less than 1 m (3 ft.) in length and 150 mm (6 inch) in width to produce a surface conforming to the plan cross section, of uniform texture, free from porous areas and a smoothness meeting the specification requirements.

Water will not be permitted to be applied to the floor surface unless it can be demonstrated to the Engineer that workability cannot be obtained. If water is permitted by the Engineer, it shall be applied in a fine mist by means of a sprayer, at a distance not to exceed 300 mm (12 inch) from the surface. Application by brushes or any other method that concentrates water will not be permitted.

- Surface Tests. After the finishing has been completed, the floor surface shall be tested by straightedge according to Article 503.17(c)(1)b.
- (3) Surface Smoothness.
  - a. All concrete bridge floors shall be tested for trueness at the expiration of the required curing or protection period. The entire surface shall be tested by means of a 5 m (16 ft.) straightedge placed parallel to the grade line and touching the surface. Variations measured from the face of the straightedge to the surface of the floor shall not exceed 5 mm (3/16 inch). Variations greater than 5 mm (3/16 inch) shall be removed by grinding or cutting. Bushhammering or any method involving impact shall not be used. Grinding or cutting shall not be done until the concrete is at least 7 days old.
- (4) Texture. All concrete bridge floors shall be textured by use of a burlap or artificial turf carpet drag in the plastic state followed by transverse diamond saw cut grooving after the bridge floor has cured.
  - a. Plastic Texture. The burlap or artificial turf shall be suitably attached to a bridge, riding on rails, or other approved device that will permit control of the time and rate of texturing. The burlap or artificial turf carpet shall have a length equal to the width of the pour or from face-to-face of curblines, as applicable. The burlap or carpet shall be laid on the concrete surface and dragged,

parallel to the centerline of the roadway, in the direction that the deck is being laid with approximately 600 mm (2 ft.) of its width in contact with the concrete surface. The drag shall be operated so as to produce a uniform appearing finish meeting the approval of the Engineer. The burlap shall be double thickness and shall be kept saturated with water while in use. The artificial turf carpet may be weighted, if necessary, for maintaining intimate contact with the concrete surface.

b. Grooving. The grooving operation shall not be started until after the expiration of the required curing or protection period and after the operation of straightedging the deck surface and correcting excessive variations by grinding or cutting has been completed.

The grooves shall be cut into the hardened concrete, perpendicular to the centerline, using mechanical saw device equipped with diamond blades that will leave grooves 3 mm wide and 5 mm  $\pm$  1.5 mm (1/8 inch wide and 3/16 inch  $\pm$  1/16 inch) deep. The Contractor shall have the option of constructing the grooves at either a random spacing of 15 mm (5/8 inch) to 30 mm (1 1/4 inch) centers with an average spacing of 22 mm (7/8 inch) or a uniform spacing of 20 mm (3/4 inch) centers. The grooving shall be stopped 300 mm (12 inches) from the faces of curbs or parapets and 50 mm  $\pm$  25 mm (2 inches  $\pm$  1 inch) from deck drains and expansion joints. If grooving must be performed as part of stage construction, the grooving may be deferred until at least two adjacent lanes have been poured.

The removal of slurry shall be continuous throughout the grooving operations. The grooving equipment shall be equipped with vacuum slurry pickup equipment which shall continuously pick up water and sawing dust, and pump the slurry to a collection tank. The Contractor shall dispose of the slurry off site according to Article 202.03.

Cleanup shall be continuous throughout the grooving operation. All grooved areas of the deck shall be flushed with clear water as soon as possible to remove any slurry material not collected by the vacuum pickup. Flushing shall be continued until all surfaces are clean to the satisfaction of the Engineer.

(d) Sidewalks, Curbs and Medians on Bridges. Forms for concrete sidewalks, curbs and medians whether placed monolithically with the bridge floor or superstructure, or with a construction joint separating them from the floor or superstructure, shall be adjusted to correct elevation, camber and alignment after the floor or superstructure has been placed and prior to the completion of the curbs, sidewalks and medians. After the concreting has been completed, they shall be struck off and finished with floats and trowels.

The edge of curbs, or walks not more than 600 mm (2 ft.) in width, shall be either beveled by the use of 20 mm (3/4 inch) triangular moulding at the top of the face forms or edged with an edging tool. The edge of walks over

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600 mm (2 ft.) in width shall be finished with an edging tool satisfactory to the Engineer. Transverse construction joints shall not be edged and transverse grooves shall not be provided.

The top surface of all walks shall be floated and troweled to a smooth finish with a steel trowel. After the water sheen has disappeared, the surface shall be given a final finish by brushing with a bristle brush. The brush shall be drawn across the walk, at right angles to the edge of the walk, with adjacent strokes slightly overlapping, producing a uniform surface moderately roughened by parallel brush marks. The stiffness of the bristles and the time at which the surface is finished shall be such as to leave well defined brush marks. The brush shall be kept clean at all times to avoid depositing mortar picked up by it during previous strokes.

(e) Concrete Parapets and Railings. Concrete parapets and railings shall not be placed until the falsework for the span has been released, rendering the span self-supporting.

Special care shall be exercised to secure smooth, tight fitting forms which can be held rigidly to line and grade and removed without injury to the concrete. All moulding, panel work and bevel strips shall be straight and true, with neatly mitered joints, and all corners in the finished work shall be true, sharp and clean cut. Alignment of forms and grade of top chamfer strips shall be checked immediately after the placing of concrete in the forms. Rail posts, openings and panels shall be constructed with vertical lines, regardless of the grade on which the railing is constructed.

(1) Slipforming. At the option of the Contractor, concrete parapets shall be constructed by slipforming in lieu of the conventional forming methods. The slipform machine shall have automatic horizontal and vertical grade control and be approved by the Engineer. Slipformed parapets shall be cured according to either Article 1020.13(a)(3) or Article 1020.13(a)(4) except that only Membrane Curing Type I compatible with linseed oil will be permitted between November 1 and April 15.

Additional tying of the rebar cage will be necessary to maintain rigidity during concrete placement. After the slipform machine has been set to proper grade and prior to concrete placement, the clearance between the slipform and reinforcement bars shall be checked by the Contractor in the presence of an inspector. This dry run check shall be made for the full distance that is anticipated to be placed in the subsequent pour. Aluminum cracker plates and guardrail inserts shall be securely tied in place. In lieu of chamfer strips at horizontal and vertical edges, radii may be used.

If the Contractor desires a greater concrete cover over the reinforcement bars for the slipform operation, the parapet cross-sectional area shall be revised according to the plan details.

The Contractor may use additional stiffening reinforcement bars to prevent movement of the required reinforcement bars during pouring. Clearances for these bars shall be the same as shown for the required bars and bars shall be epoxy coated. If the additional reinforcement is used it shall be at no additional cost to the Department.

The Contractor may use alternate reinforcement as shown in the plans at no additional cost to the Department. The alternate reinforcement shall be epoxy coated.

The top portion of the joint shall be sawcut to the full depth as shown on the plans within 4 to 24 hours after concrete placement. The sawcut shall be approximately 10 mm (3/8 inch) wide and shall be performed with power saws mounted on a frame with guidance provisions. The joints shall be sealed with an approved polysulfide sealer to a minimum depth of 25 mm (1 inch). Cork, hemp or other compressible material may be used as a backer. The sawcut will not require chamfered edges.

Ends of the parapet shall be formed and the forms securely braced. Parapet sections at light standards, shall be formed for a minimum distance of 1.2 m (4 ft.) on each side of the exception.

Equipment or methods which result in dimensions outside the tolerance limits shall not be used. Parapets having dimensions outside the tolerance limits will be rejected and shall be removed and replaced. The maximum variance of actual to proposed longitudinal alignment shall not exceed +20 mm (3/4 inch) with no more than 6 mm in 3 m (1/4" in 10 ft.). Notwithstanding this tolerance, abrupt variance in actual alignment of 13 mm in 3 m (1/2" in 10 ft.) will be cause for rejection of the parapet.

In addition, all surfaces shall be checked with a 3-m (10-ft.) straight edge furnished and used by the Contractor as the concrete is extruded from the slipform. Parapets having surface irregularities greater than 6 mm in 3 m (1/4 inch in 10 ft.) shall be corrected immediately at the Contractor's expense. Continued variations in the barrier surface exceeding 6 mm in 3 m (1/4 inch in 10 ft.) will not be permitted and remedial action shall immediately be taken to correct the problem.

Any deformations or bulges remaining after the initial set shall be removed by grinding after the concrete has hardened. The vertical surface at the base of the barrier shall be trowelled true after passage of the slipform machine. All holes and honeycomb shall be patched immediately. The entire surface shall receive a light vertical brush finish before final set.

**503.18 Waterproofing.** When specified, designated surfaces of concrete structures shall be waterproofed by one of the following methods. Surfaces below the ground, which are to be waterproofed, shall be given either one coat of Asphalt Primer: RC-70, and 2 mop coats of Petroleum Asphalt: AWP Type A; or 2 mop coats of Asphalt Emulsion for Waterproofing. Surfaces above the ground line which are to be waterproofed shall be given one coat of Asphalt Primer: RC-70 and 2 mop coats of Petroleum Asphalt: AWP, Type B. With the approval of the Engineer, spraying will be permitted in lieu of mopping.

The surfaces to be waterproofed shall be smooth and free from projections or porous places. The surface shall be cleaned of dust, dirt, grease and loose particles and shall be dry at the time the waterproofing is applied. Petroleum Asphalt waterproofing shall not be applied until at least 7 days have elapsed after placing of the concrete. Asphalt Emulsion waterproofing may be applied as soon as the forms are removed. No waterproofing shall be done in wet weather, or if local conditions indicate that rain is imminent, or when the temperature of the air in the shade is below 10 °C (50 °F.), without the written permission of the Engineer, except as specified for Asphalt Emulsion.

When waterproofing with Petroleum Asphalt, the primer shall be applied to the surface of the concrete in a uniform coating and may be applied without heating. The primer shall be applied at least 24 hours before applying the first mopping of hot bitumen. The bitumen for each of the 2 mop coats shall be heated to a temperature which will permit uniform application. Asphalt shall not be heated above 175 °C (350 °F.). The amount of bitumen applied in the 2 moppings shall be approximately 3 L/m<sup>2</sup> (8 gals. per 100 sq. ft.) of finished work. If any imperfections appear in the waterproofing, additional coats will be required.

When waterproofing with Asphalt Emulsion, two uniform coats, free from holes or holidays, shall be applied. The second coat shall be applied as soon as the first coat has dried. The minimum total quantity applied in the two coats shall be 1 L/m² (3 gals. per 100 sq. ft.) When the temperature of air in the shade is below 7 °C (45 °F.), and the requirements of Article 1020.13(e) have been complied with, Asphalt Emulsion waterproofing may be applied down to a temperature of 0 °C (32 °F.). Regardless of the temperature during application the material shall be kept at a temperature above 10 °C (50 °F.). A minimum drying time of 24 hours is required before backfilling, but no backfilling shall commence until the requirements of Article 502.10 are met.

**503.19 Protective Coat Application.** When specified, a protective surface treatment consisting of 2 coats of boiled linseed oil mixture shall be applied to the entire top surface of the bridge deck, the top surfaces of the sidewalks, the hubguards, and the tops and inside vertical faces of the sidewalk parapets, end posts and wings. The concrete must be at least 14 days old and all saw cut grooving and cleanup operations must be completed before application of the oil mixture.

Application of the protective coat shall be according to the requirements of Article 420.21, except that an air blast shall be directed over the surfaces to be treated immediately before application of the mixture so that all dust will be removed and hand methods of application will be permitted.

**503.20** Opening Structures to Traffic. The concrete superstructures shall be opened to traffic according to Article 701.05(d)(1).

#### 503.21 Method of Measurement.

- (a) Contract Quantities. The requirements for the use of Contract Quantities shall conform to Article 202.07(a).
- (b) Measured Quantities. All concrete will be measured for payment and the volume computed in cubic meters (cubic yards). In computing the volume of concrete for payment, the dimensions used will be those shown on the plans or ordered in writing by the Engineer. Increased quantities resulting

from the use of the slipform option for concrete parapets will not be measured for payment. Deductions will be made for the volume of piling, except for steel H pile, encased in the concrete. No deduction will be made for the volume of concrete displaced by steel reinforcement, drain holes, floor drains and expansion joint material. The quantity of concrete involved in scoring and chamfers 1300 mm<sup>2</sup> (2 sq. inch) or less in cross sectional areas will be neglected in all measurements for payment.

When shown on the plans or ordered in writing by the Engineer, concrete for foundation seals will be measured for payment within the cofferdam sheeting. The vertical dimension used in computing the volume will be the average thickness of the seal between the top of the seal not to exceed the elevation shown on the plans for the bottom of the footing and the bottom of the excavation, but in no case lower than the elevation shown on the plans for the bottom of the foundation seal. The horizontal dimensions used will be the average measurement from center to center of the interlocks of the sheet piling in opposite walls of the cofferdam, but in no case will these dimensions be taken as more than 600 mm (2 ft.) beyond the neat lines of the footing in any direction, except that provision may be made for a sump at one end of the cofferdam if necessary.

Preformed elastomeric compression joint seals for bridge expansion joints will be measured for payment in place in meters (feet).

Neoprene expansion joints will be measured for payment in place along the centerline of the joint in meters (feet).

Bridge deck grooving will be measured for payment in place and the area computed in square meters (square yards). In computing the area for payment, no deductions will be made for grooving omissions at deck drains, expansion joints or longitudinal joints or lane lines.

The areas upon which the protective coat has been applied will be measured for payment and computed in square meters (square yards).

Joint fillers, water seals, drain holes, floor drains and welded wire fabric reinforcement, except when specified, will not be measured for payment.

The installing of conduits, sleeves and metal inserts for hangers, the installing or erecting and painting of structural steel that cannot be completely installed or erected prior to the concrete work, and the adjusting of steel members or parts that cannot be finally adjusted prior to the concrete work, will not be measured for payment when the materials for this work are furnished to the Contractor without cost to the Contractor and the contract does not provide for separate payment for this work.

Rubbed finish, when required, will be measured for payment in square meters (square feet) of surface area rubbed.

No measurement or other allowance will be made for work or materials for forms, falsework, shoring, bracing, pumping or other incidentals necessary to complete the work as required.

The quantities of items, other than above, which constitute the completed structure will be measured for payment as specified for the items involved.

**503.22 Basis of Payment.** Concrete for cast-in-place structures and superstructures will be paid for at the contract unit price per cubic meter (cubic yard) for CONCRETE STRUCTURES and for CONCRETE SUPERSTRUCTURE.

Other cast-in-place concrete for structures will be paid for at the contract unit prices per cubic meter (cubic yard) for CONCRETE HANDRAIL, CLASS MS CONCRETE and SEAL COAT CONCRETE. When one class of concrete is substituted for another, as provided by Article 503.02, the class of concrete to be paid for will be that specified. When no unit price is provided for Seal Coat Concrete, foundation seals ordered in writing by the Engineer will be paid for according to Article 109.04.

Reinforcement will be measured and paid for according to Section 508.

Expansion bolts, when specified, will be paid for according to Article 540.08.

Rubbed finish will be paid for at the contract unit price per square meter (square foot) for RUBBED FINISH.

Floor drains, other than Frames and Grates, will be paid for at the contract unit price each for FLOOR DRAINS.

Preformed elastomeric compression joint seals for bridge expansion joints shall be paid for at the contract unit price per meter (foot) for PREFORMED JOINT SEAL of the size specified.

Texturing of bridge decks by saw cut grooving will be paid for at the contract unit price per square meter (square yard) for BRIDGE DECK GROOVING, which price shall include all labor, materials, equipment and incidental items necessary to complete the work. The steel expansion dams will be paid for as structural steel according to Section 505.

Neoprene expansion joints will be paid for at the contract unit price per meter (foot) for NEOPRENE EXPANSION JOINT of the expansion range size specified, NEOPRENE EXPANSION JOINT (DAM), or NEOPRENE EXPANSION JOINT (LONGITUDINAL). This price shall be payment in full for anchor bolts, threaded rods, threaded studs, anchor studs, installing hardware, sealant and adhesive, seat preparation, and installation. No additional compensation will be allowed the Contractor for correction of joint seats constructed by the Contractor under other items of work or for correction of loose, long or misaligned anchor bolts.

Items of structural steel, when specified, will be measured and paid for according to Section 505.

Elastomeric bearing assemblies, furnished and installed, including the elastomer, structural steel bearing plates, TFE sheets, stainless steel sheets, and other component parts, as specified, will be paid for at the contract unit price each for ELASTOMERIC BEARING ASSEMBLY of the type designated. Side retainer, anchor bolts, and shim plates will be measured and paid for according to Section 505. When an Elastomeric Bearing Assembly is requested by the Department for testing, the furnishing and delivering of the additional assembly will be paid for according to Article 109.04.

When the fabrication and erection of elastomeric bearings and other collateral work are accomplished under separate contracts, the applicable requirements of Article 505.09 shall apply.

Fabricated elastomeric bearings and other materials complying with the requirements of this item, furnished and accepted, will be paid for at the contract unit price each for FURNISHING ELASTOMERIC BEARING ASSEMBLY of the type designated.

Storage and care of fabricated elastomeric bearing assemblies by the Fabrication Contractor beyond the specified storage period, will be paid for at the contract unit price per calendar day for STORAGE OF ELASTOMERIC BEARING ASSEMBLIES if a pay item is provided for in the contract, or will be paid for according to Article 109.04 if a pay item is not provided in the contract.

Elastomeric bearing and other materials fabricated under this item erected according to the requirements of the specifications, and accepted, will be paid for at the contract unit price each for ERECTING ELASTOMERIC BEARING ASSEMBLY of the type designated.

Protective coat, when specified, will be paid for at the contract unit price per square meter (square yard) for PROTECTIVE COAT, which price will be payment in full for the 2 applications.

Waterproofing, as specified, will not be paid for separately but shall be considered as included in the unit price bid for the concrete item involved.

Concrete protected according to Article 1020.13(e) may be paid for at the adjusted unit prices which will be the following percentages of the contract unit price for the classes of concrete involved. These adjustments will be made only when they are authorized in writing by the Engineer. No adjustment will be made in the contract unit prices for any concrete if winter work is necessary to meet the required completion dates specified in the contract.

The adjusted unit prices specified for concrete shall be considered as compensation in full for the construction of the concrete, for protection and heating, and for all additional costs incurred because of winter construction. No adjustment will be made in the contract unit price of any other item of work performed according to these requirements.

No adjustment will be made for filling metal shell piles.

UNIT PRICE ADJUSTMENTS	
Type of Construction	Percent Adjustment in Unit Price
For concrete in substructures, culverts (having a waterway opening of more than 1 m <sup>2</sup> (10 sq. ft.), pump houses, and retaining walls (except concrete pilings, footings and seal coats):  When protected by:  Protection Method II  Protection Method I	115% 110%
For concrete in superstructures:  When protected by: Protection Method II Protection Method I	123% 115%
For concrete in footings:  When protected by:  Protection Method I, II or III, and slope walls  Protection Method I or III	107%

# **SECTION 504. PRECAST CONCRETE STRUCTURES**

**504.01 Description.** This work shall consist of the construction of structures or portions thereof, of precast or precast, prestressed concrete structural members, manufactured and erected as specified.

**504.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 - Materials:

	Item	Article/Section
(a)	Preformed Bearing Pads	1082
	Reinforcement Bars	
(c)	Prestressing Steel	1006.10
(d)	Welded Wire Fabric	1006.10
(e)	Transverse Tie Rods and Dowel Rods	1006.06
(f)	Non-Shrink Grout	1024
(g)	Portland Cement Concrete	1020

**504.03 Equipment.** Equipment shall meet the requirements of the following Articles of Section 1100 - Equipment:

	Item	Article/Section
(a)	Concrete Mixers	1103.01(a)
	Batching and Weighing Equipment	
	Water Supply Equipment	
	Hand Vibrator	
	Vibrating Screed	
	Truck Mixer (Note 1)	

Note 1. A truck mixer may be used providing that it meets the requirements as specified in the Manual for Inspectors of Precast, Prestressed Concrete Products.

Plant equipment for manufacturing the precast concrete units shall meet the approval of the Engineer.

## CONSTRUCTION REQUIREMENTS

- **504.04 General.** Precast concrete structural members shall be manufactured in a plant or other location where strict control over the manufacturing procedure is maintained at all times. Plants or other locations manufacturing the members must be approved by the Engineer. Construction requirements shall be according to Section 503, and as specified.
  - (a) Shop Drawings. The Contractor shall submit shop drawings to the Engineer for approval. Prints of the drawings shall be submitted in duplicate, with a record of any discrepancies and necessary changes in the plans noted. These drawings shall be on sheets 594 mm (24 inches) by 841 mm (36 inches) in size and of adequate quality for microfilming by the Department. All drawings shall be completely titled according to the contract plans and shall pertain to only one structure. Upon approval, the Contractor shall furnish 3 or more prints of the approved drawings, which shall become a part of the original contract and shall be subject to all general or Special Provisions governing it. Changes on approved drawings shall be subject to the approval of the Engineer and a record of all such changes shall be supplied to the Engineer. The Contractor shall be responsible for the accuracy of the drawings even though approved by the Engineer.
  - (b) Forms. Forms shall meet the requirements of Article 503.06, except as specified for precast, prestressed members.
  - (c) Reinforcement and Accessories. Reinforcement bars shall meet the requirements of Section 508. The bars shall be rigidly fastened together by wire ties, and extra tie bars shall be furnished as may be necessary for maintaining satisfactory rigidity during handling and placing. Spot welding will be permitted where approved by the Engineer. Sufficient chairs shall be furnished for supporting the reinforcement at the proper distance from horizontal surfaces. Chairs may also be used as spacers to hold reinforcement at the proper distance from vertical surfaces. The concrete cover over all reinforcement shall be within ± 5 mm (± 1/4 inch) of the specified cover.

Welded wire fabric shall be accurately bent and tied in place.

Miscellaneous accessories to be cast into the concrete or for forming holes or recesses shall be carefully located and rigidly held in place by bolts, clamps or other effective means. If paper tubes are used for vertical dowel holes, or other vertical holes which require grouting, they shall be removed before transportation to the construction site.

(d) Concrete. The materials shall be combined so as to produce a concrete meeting all the requirements specified in Articles 1020.04 and 1020.05 for Class PC Concrete for precast structures and for Class PS Concrete for precast, prestressed concrete members. It shall be the Contractor's responsibility to determine the proportions of the materials for the concrete, and to exercise quality control with respect to the mixture, so that each batch of concrete entering into the members will meet the requirements specified. Batches of concrete not meeting the requirements as to slump and entrained air content will be rejected.

Before the work begins, the Contractor shall furnish the Engineer a listing of the name, source, brand or type and/or supplier for each of the materials, and shall secure the Engineer's approval of the proportions of cement, fine aggregate, coarse aggregate, admixtures and water the Contractor proposes to use.

**504.05 Precast Concrete Members.** Bridge slabs, pile caps and other precast concrete structural members, which may be specified, shall conform to the following specific requirements. All reinforcement bars, tie bolts, anchor dowels, bearing pads, inserts, grout and mortar required for the manufacture and erection of the units shall be included.

(a) Manufacturing. The Contractor shall make, cure and test the concrete test specimens as directed by the Engineer. A minimum of 4 test specimens of concrete shall be made for each 7 units, or a minimum of 4 specimens per day shall be made if less than 7 units are constructed. Test specimens shall be 150-mm (6-inch) diameter by 300-mm (12-inch) cylinders.

The roadway surface of bridge slabs shall be finished with a wood float and the exposed face and top of curb section shall be finished according to Article 503.16(a).

Side forms may be removed when, by so doing, no distortion, slump or misalignment of the concrete will be caused.

Curing shall be as specified in Article 1020.13, and shall be continued until the concrete has attained a compressive strength of not less than 30 MPa (4500 psi). Steam curing will also be permitted, provided that the method and its details meet the approval of the Engineer.

The units shall remain on the bottom supporting forms until the concrete has attained a compressive strength of not less than 14 MPa (2000 psi). The curing may then be interrupted while the units are being moved to a storage area for further curing. All test specimens shall remain with the units and shall be subjected to the same curing as the units until the time

of testing.

When the concrete has attained a compressive strength of not less than 30 MPa (4500 psi), but not prior to 4 days after casting, the units may be loaded, shipped and used.

Only those members bearing identification marks of acceptance by the Department will be permitted for use in the construction.

The number of test specimens available should be sufficient for determining the specified concrete strengths accurately. If the supply of test cylinders becomes exhausted, cores for additional tests shall be taken from the units as directed by the Engineer.

- (b) Tolerance of Dimensions. The 4 sides of the members shall not vary more than 3 mm (1/8 inch) for the full depth of the member when tested with a straightedge in a vertical direction, nor more than 5 mm (1/4 inch) in the full length of the member when tested with a straightedge in a horizontal direction; nor shall the surface of the member deviate more than 3 mm (1/8 inch) from a straight line 3 m (10 ft.) long connecting two points on the member's surface.
- (c) Handling and Placing. The members shall be handled in a manner that will not cause crushing, spalling or undue marring of the concrete.

The ends of precast members shall not be permitted to extend a distance exceeding the depth of the member on any vehicle, bolster or other point of bearing during hauling or stockpiling.

Precast members shall be handled with a suitable hoisting device or crane provided with a spreader sling of sufficient capacity to handle the members. The spreader shall be of sufficient length to prevent horizontal forces in the member due to lifting, and shall be equipped with leads and hooks at each end. For the purpose of engaging the threaded inserts provided in the member, the manufacturer shall provide a sufficient number of eye bolts of proper size.

Before lifting the member, all lifting inserts in each end shall be fully engaged with the spreader lead hooks. In the event that raising by alternate lifting and blocking of opposite ends is performed, the lifted end shall not be rotated unless a proper pivoting device for the opposite end has been provided.

Erection of precast bridge slabs shall commence at the centerline and proceed, one slab at a time, working out to the curb. As each slab is placed, the transverse tie bars shall be inserted and secured. Any shifting of the beams must be done while they are held free of the supports by the hoisting device or crane. The use of a steel pinch bar will not be permitted.

The abutting edges of each unit shall be carefully cleaned of any concrete or extraneous matter in order that the longitudinal joints can be bolted tightly together.

Care shall be exercised to keep bridge seats free of foreign material when placing the slabs. After the units have been placed and fastened together and the end anchor dowels are placed, the longitudinal joints between the units shall be filled with a very dry mix mortar consisting of one part cement, one part sand, and water; the amount of water to be determined by the Engineer. The mortar shall be cured for a period of not less than 3 days by the wetted burlap method according to Article 1020.13 (a)(3). Curing shall commence as soon as practicable after mortar placement joints shall be filled.

Pile caps shall be carefully lowered into their proper position over the piles and to the specified elevation. After the units have been placed, the recess holes shall be filled with a dry mix mortar consisting of one part cement, one part sand, one and one-half parts chips or pea gravel, and water; the amount of water to be determined by the Engineer. To ensure that the recess holes are completely filled, the mortar shall be vibrated into place.

**504.06 Precast, Prestressed Concrete Members.** Deck beams, I-beams, Bulb T-beams, and other prestressed concrete structural members which are specified shall conform to the following specific requirements. All reinforcement bars, inserts and accessories cast in the members, and all tie assemblies, threaded rods, anchor dowels, bearing pads and shims, joint material, mortar, grout, and other materials necessary and required for the manufacture and erection of the members shall be included.

The Manual for Inspectors of Precast, Prestressed Concrete Products in effect on the date of invitation for bids, setting forth policies adopted by the Department that have been observed to produce satisfactory results, shall govern with respect to details of procedure, except that modifications that have been shown to produce equally satisfactory or superior results may be approved. This Manual is available without charge, upon request, from the Engineer.

Shop drawings will be required according to the requirements of Article 504.04(a).

(a) Prestressing Steel. Each reel of the prestressing steel shall be identified by the reel number. Strands from more than one source shall not be used in any one tensioning operation. The Contractor shall furnish to the Engineer a test sample 2 m (7 ft.) in length from each coil or reel. The test sample shall be cut with a torch in a manner that will weld or fuse together the ends of the individual wires of the strand. Samples shall be identified by reel number. They shall not be coiled for shipment to the laboratory for testing.

All prestressing strands shall be free of dirt, oil, paint, corrosion or any foreign material that may prevent bond between the strands and the concrete. The use of prestressing strands having kinks, bends, nicks or other defects will not be permitted.

(b) Lifting Devices and Void Tubes. Lifting devices shall be fabricated and anchored or tied in place, as shown on the plans. Other types may be used upon written request by the Contractor and with written approval of the Engineer. Unless otherwise provided, all deck beams shall have void tube drains and air vents. The forming of the drains and vents, their location and the material used for the forming shall be approved by the Engineer. When no longer needed, the air vents shall be filled as directed by the Engineer.

Void tubes or inside forms shall be as shown on the plans and approved by the Engineer. They shall be composed of materials and of a design that will enable them to withstand the forces imposed upon them during the fabrication of the deck beams without substantial deformation such as bulging, sagging or collapsing. It is the Contractor's responsibility to fabricate a void that meets the requirements of the plans. Contractors who have not previously manufactured members with void tubes, or who are using a type of void tube or void tube materials not previously used or proven satisfactory, will be required to construct a test section of the member, not less than 3 m (10 ft.) in length, so the placement and behavior of the tube may be observed by the Engineer prior to approval. Void tubes shall be protected against damage during storing and handling. Damaged void tubes shall not be used.

- (c) Manufacturing. The members shall be pretensioned. The adequacy and suitability of the equipment used to perform the work shall be subject to review by the Engineer. All phases concerning the method of pretensioning, use of hydraulic jacks and gages, cutting strands, curing, plant handling, transporting and other operations necessary and incidental to the construction and delivery of members, shall be subject to approval of the Engineer.
  - (1) Prestressing Equipment and Operation. Hydraulic jacks, screw jacks or other approved equipment shall be used for tensioning the strands. The tensioning system shall be equipped with gages or other indicating devices for accurate determination of the loads applied to the strands. All devices shall be calibrated by a laboratory approved by the Engineer and a certified calibration curve shall accompany each. Recalibration shall be made when directed by the Engineer, and the Engineer reserves the right to check the calibration at any time to assure the stress in the prestressing steel can be accurately computed at all times. Hydraulic pressure gages shall have a full pressure capacity of approximately twice the normal working pressure. A separate approved system of applying and measuring pre-loads shall be employed when more than one strand is to be tensioned in the same operation.

All tensioning of strands shall be performed in the presence of the Engineer, and a record shall be kept of the jacking force and the strand elongation produced. No tensioning of strands will be permitted at temperatures below -12 °C (10 °F.). Several members may be cast in one continuous line, provided that all members are fabricated without undue intervening delay. When the temperature at the time of tensioning is such that correction must be made to compensate for change in strand stresses, all members on the bed shall be cast in a continuous pour; otherwise, the time intervening between the casting of the first and last member on the bed shall not exceed 4 days. The Contractor shall take effective safety measures to prevent injuries of

personnel due to breakage of strands or failure of anchorage devices during tensioning operations.

After completion of the tensioning, anchorage devices for holding the stressed strands shall permit no slippage, and the strands shall be held in the proper position on the bed within a tolerance of  $\pm$  5 mm ( $\pm$  1/4 inch). Sag of the bottom row of strands shall be eliminated by the use of wire chairs having plastic coated tips or plastic chairs.

The following tabulation shows the total prestressing loads to which individual strands of various sizes shall be tensioned:

*Fu = 1860 MPa			
Nominal Nominal Total Prestressing Load, Diameter, Steel Area, N			
mm	Sq. mm	Stress Relieved	Low- Relaxation
9.53 11.11 12.70	54.84 74.19 98.71	71400 96600 128500	76500 103500 137700

*Fu = 270 KSI (Grade 270)			
Nominal Nominal Total Prestressing Load, Diameter, Steel Area, Ibs.			
Inch	Sq. Inch	Stress Relieved	Low- Relaxation
3/8 7/16 1/2	0.085 0.115 0.153	16,000 21,700 28,900	17,200 23,200 30,900

<sup>\*</sup>Fu = Minimum specified ultimate tensile strength.

The prestressing strands shall be accurately placed and held in position on the casting bed, anchored at the fixed end and stressed to the required tension. Regardless of the method used, each strand individually shall be initially tensioned to a pre-load of 9 kN (2000 lbs.), unless otherwise directed by the Engineer, and a mark against which to measure elongation under subsequent loading shall be placed on the strand. The gage and elongation measurements for subsequent loadings shall include allowances for slippage and thermal expansion of the strands.

When the strands are to be tensioned individually, the load on each shall then be increased to the required amount as indicated by the gage, and the accuracy of the increase shall be checked by measurement of the elongation of the strand, and the load so determined shall equal that indicated by the gage within 3 percent of

the required load.

If 2 or more strands are to be tensioned simultaneously by the same jack, the load shall be increased until the final load on each strand is attained, as indicated by measurements of the elongation of the strands, and the combined load on the strands so determined shall equal that shown on the gage within 3 percent of the required load. The Contractor shall furnish and have available at least 2 load cells of approved design, which shall be placed on strands on opposite sides of the line of pull, as designated by the Engineer, for further verification of the accuracy of the load and for checking the uniformity of pull on individual strands.

When deflected strands are required, these shall be held in proper position with respect to the soffit plate by suitable anchoring devices that will cause a minimum of friction during tensioning. Each deflected strand shall be pre-loaded and individually tensioned to the full load, as described above, and the load as determined from the strand elongation shall check that indicated by the gage within 5 percent of the total load required. If a less satisfactory check is obtained, the strand shall be tensioned from both ends of the casting bed and the load as calculated from the sum of the strand elongations shall check that indicated by the gage within 5 percent of the total load required.

The prestressing force shall be transferred to the concrete only after it has attained the specified age and strength, and only with the approval of the Engineer. The release of the strands shall be accomplished in a manner that will create a minimum of eccentric force acting upon the beam. Unless the method suggested in the Manual for Inspectors of Precast, Prestressed Concrete Products is followed, and in any case where draped strands are involved, the Contractor shall submit for the approval of the Engineer the pattern the Contractor proposes to use in releasing the strands. Except when the ends are to be encased in concrete, the prestressing strands shall be trimmed within 3 mm (1/8 inch) of the concrete and the ends of the members shall be given 2 coats of an asphalt paint. The release of the strands shall be accomplished as soon as the required strength and age have been attained, and while the concrete is still warm if steam curing is used.

(2) Forms. Exterior forms shall be steel. Inside forms or void tubes for deck beams may be of treated cardboard, plywood or other suitable materials.

The casting bed shall have a concrete deck to which the form grillage and soffit plates shall be adequately anchored. Soffit plates shall be accurately centered, aligned and leveled to the same plane.

Side forms shall have form plates of sufficient thickness, shall be sufficiently braced, and shall be anchored so as to withstand the forces due to vibratory placement of the concrete and to maintain correct alignment. The ends or sides of adjacent sections of form which are butt-joined shall match smoothly and tightly and shall result in proper alignment. The side forms shall be cross tied above the finished

surface of the member at sufficiently close spacing to maintain true cross sectional dimensions. Side forms for deck beams shall be provided with test holes at sufficiently close spacing for checking the wall thickness of the beams during the construction operations.

The design of bulkheads shall be such that they can be placed and maintained in correct position between the side forms. Clamps, bolts or other devices connecting the bulkheads to the side forms shall be capable of being removed or loosened before steam curing is applied, so that expansion of the side forms may occur freely and without damage to the beams. The bulkheads shall have slots or holes, conforming to the strand pattern, to permit passage of the prestressing strands. Sufficient space shall be left between bulkheads to properly permit the operations necessary for releasing the strands.

In the case of deck beams, provision shall be made for holding the inside forms or void tubes accurately in place to prevent flotation and misalignment.

All exposed outside edges shall be beveled or chamfered as shown. Leakage of mortar will not be permitted. Joints between soffit, side forms and bulkheads shall be tight and, if necessary, shall be gasketed with rubber which may also be used to provide the corner chamfers. Plugging of holes and slots in the forms shall be neatly done so that the finished members shall have a professional appearance. Before the concreting operations begin, the forms and casting bed shall be treated with a suitable form oil or other approved material to prevent bonding of the concrete. Extreme care shall be exercised to prevent the coating of prestressing strands and reinforcement bars with such material, and any strands or bars so contaminated shall be satisfactorily cleaned or replaced. After forms are removed, and prior to transporting deck beams, all form oil or other form release material residue shall be removed from the keyway surfaces by sandblasting.

Forms shall be free from paint or other protective substance that may cling to the surface of the members. Forms not thoroughly cleaned after prior use shall not be used.

If during the casting it becomes apparent that forms have deteriorated to the degree that members no longer can be constructed without approaching or exceeding the dimensional tolerance limits, the Engineer may order production suspended with respect to the use of the unsatisfactory forms until they have been completely renovated or replaced.

(3) Testing of Concrete. The Contractor shall furnish, and have available for use of the Engineer, approved equipment for slump and air content determinations, and sufficient molds for making the specified number of cylindrical test specimens.

Tests of the concrete mixture for air content and slump will be performed after delivery to the casting site and before the concrete is incorporated into the members. The slump of the concrete shall be no greater than is necessary for proper placement and consolidation. The policies adopted by the Department as set forth in the Manual for Inspectors of Precast, Prestressed Concrete Products will govern for slump.

A minimum of 6 test cylinders shall be made from the concrete mixture per casting bed. The cylinders shall be cast from samples taken from batches designated by the Engineer after delivery to the casting site, and as the concrete mixture is being discharged for incorporation into the member.

The cylinders shall be placed with and cured in the same manner as the member. The position of the cylinders during curing shall be such that no undue advantage is given to them, as compared to any part of the member, with respect to environment favorable to gain in strength. The cylinders shall remain with the member until removed for testing or until the prestress forces are transferred to the concrete in the member. The cylinders reserved for the 28-day tests shall be cured at the same location, and in exactly the same manner, length of time and under the same atmospheric conditions as the members they represent. The Contractor shall furnish an approved testing machine and shall perform the testing of the cylinders, but the tests shall be performed only in the presence of the Engineer. The Engineer reserves the right to check the accuracy of the testing machine prior to or at any time during the period of performing the tests.

and Consolidating. The forms, prestressing reinforcement and accessories shall be inspected and approved by the Engineer immediately prior to placing the concrete, and no concrete shall be placed until such inspection has been made, but such approval shall not relieve the Contractor of responsibility as to the results obtained. Concrete shall be placed in horizontal lifts and Internal vibrators shall have a consolidated by internal vibration. vibrating head not more than 30 mm (1 1/4 inches) in diameter. At locations of relative massive concrete and away from the prestressing strands, where, with the exercise of ordinary care, the reinforcing steel will not be displaced, the Engineer may approve the use of larger vibrators. External vibration may be used in conjunction with the internal vibration, if approved by the Engineer. Vibration shall be performed with care to avoid the displacement of reinforcement, prestressing steel, and accessories, and to ensure satisfactory consolidation.

In the case of deck beams, the bottom slab shall be placed, consolidated with vibratory equipment and screeded or tamped to the proper thickness before the inside forms or void tubes and the top bar reinforcement is placed. Workers will not be permitted to walk on top of the inside forms, and concrete will not be permitted to accumulate excessively on them during the period of placing the mixture between the outside and inside forms. In the case of members utilizing cylindrical void tubes, the Engineer may approve the placing of the void tubes, and the positioning of the reinforcement before concrete operations begin, provided that it can be assured that the void tubes

will be correctly located in the finished member. Fabric reinforcement when used shall be placed as shown on the plans before the side forms are set.

The concreting operations shall proceed at a rate sufficient to ensure that no seams or cold joints shall exist. Vibration of each lift shall be sufficient to eliminate honeycomb and excess water and air pockets, and the vibrators shall be inserted completely through the lift and barely into the preceding lift to ensure proper unification at the junctures of all lifts. The vibrator shall be inserted and removed slowly but will not be permitted to remain stationary in the concrete and shall not be forced between strands.

- (5) Finishing. The top surface of deck beams shall be screeded with a straightedge and then finished with a wooden hand float. The top surface of I-beams and Bulb T-beams shall be finished initially with a wooden hand float. Further finishing shall be delayed until the water sheen appears, but not to the point of rendering further manipulation ineffective. The surface then shall be roughened with a suitable stiff-bristled broom or wire brush drawn in transverse direction removing any laitance present and breaking up the water sheen. The corrugations formed shall be uniform in appearance and in no case more than 5 mm (1/4 inch) in depth. Surfaces that will be exposed to view in the completed structure shall be finished according to Article 503.16.
- (6) Curing. Members shall be kept wet during the entire period of curing. This may be accomplished by the method specified in Article 1020.13(d) or by steam curing as specified herein or by other methods approved by the Engineer.

Air vents shall be in place, and shall be so arranged that no water can enter the void tubes during the curing of the members. Bolts, clamps or other devices for holding bulkheads, recess blocks and inserts in place during casting shall be removed or loosened to permit free expansion of the forms, without damage to the members, when steam curing is used.

As soon as each member is finished, it shall be covered with not less than 2 layers of wet burlap or other material approved by the Engineer, and placed in contact with the exposed surface. A preset period shall be determined before the steam is applied. A preset period of less than 4 hours is permitted if determined according to ASTM Designation C 403, except that 1/2 hour shall be added to the determined time. The use of a hand penetrometer is permissible. When the ambient temperature is below 10 °C (50 °F.), steam shall also be applied during the preset period, but only at a rate sufficient to keep the air surrounding the beam at a temperature between 10 °C and 20 °C (50 °F. and 70 °F.).

Steam shall be applied from pipes with perforations at suitable intervals laid along each side of the member, or by other approved arrangement. Jets of steam will not be permitted to impinge directly

against the member, or form, or test specimens. Provisions shall be made for effective circulation of the steam around and over the top of the members, by frames at suitable intervals, extending at least 100 mm (4 inches) over the sides of the form, or other approved arrangement, and draping over them a suitable covering, providing a complete closure around the member and steam pipes.

Steam shall be applied in a manner that shall not increase the temperature of the air surrounding the members faster than 4 °C (40 °F.) per hour. The curing temperature shall be reasonably uniform around each member and shall not exceed 70 °C (160 °F.). When the steam curing is discontinued, the decrease in the temperature within the closure shall be at a rate not exceeding 4 °C (40 °F.) per hour.

The Contractor shall furnish and have available for the use of the Engineer a minimum of 2 portable recording thermometers, but not less than one for each 45 m (150 ft.) of closure, for use in determining the magnitude and degree of uniformity of temperatures within the closure.

The steam curing shall create a moist, humid condition under the closure, and there shall be no evidence of dehydration of the concrete. Perceptible drying of the wet burlap initially placed on the members will be considered as indicating that the steam curing does not supply sufficient moisture, and a soaker hose placed on top of the members shall be used to augment the steam curing, or other approved corrective measures shall be taken. Forms shall not be removed during the steam curing, except as approved by the Engineer and by a procedure approved by the Engineer. If the forms are removed, wet burlap shall be draped over the sides and ends of the member and the steam curing resumed immediately.



The prestressing force shall not be transferred to any member before the concrete has attained the compressive strength of 30 MPa (4000 psi) or other higher compressive strength specified on the plans, as determined from tests of 150-mm (6-inch) by 300-mm (12-inch) cylinders cured with the member and representative of the concrete used in it. Further curing of the member after detensioning is at the option of the producer. However, members cannot be shipped until 28-day strengths have been attained and members have a yard age of at least 4 days.

(7) Weather Precautions. Concrete shall not be placed at outdoor plants during inclement weather. If the concreting operations are in progress when the adverse weather conditions occur, protective covering shall immediately be placed over all exposed concrete. If necessary, the completion of a member in the process of manufacture will be permitted, provided that substantial increase in the water-cement ratio, because of rain, will not occur. Such member will be accepted only if it meets the requirements of the Specifications.

Concrete shall not be placed at ambient temperatures below freezing,

unless there exists adequate assurance that the organization of the work and the facilities available are such that the work will be completed and steam applied before damage to the concrete occurs. The casting bed and forms shall be preheated with steam but no water shall remain on the bed, and the concrete shall be delivered at the forms at a temperature not less than 10 °C (50 °F.) nor more than 32 °C (90 °F.). Concreting operations shall not start when the ambient temperature is below -4 °C (25 °F.) and the Engineer may suspend the work at the completion of any one member if there is danger of damage to the concrete.

(d) Inspection of Completed Members. The completed members will be inspected after release of the strands and while they are still on the casting beds or in a holding area, to determine their acceptability under the specification requirements, as of that date. They will be inspected again just prior to shipment, after arrival on the construction site, and after placement in the structure for possible damage during handling, storing, transporting and erecting.

All inspection of completed members will be performed according to the provisions contained in the Manual for Inspectors of Precast, Prestressed Concrete Products.

The Engineer will determine the kind, type and extent of cracks and surface defects such as honeycomb and chipped edges or corners that will be tolerated. All such cracks and surface defects shall be repaired as specified in the Manual for Inspectors of Precast, Prestressed Concrete Products. Members shall be cast without cracks or other defects and true to the dimensions shown on the plans. It is recognized that certain cracks and surface defects may not be detrimental from the standpoint of structural integrity and may be relatively harmless if remedied by proper repair, and that deviations in dimensions from those shown on the plans, within certain limits, can be tolerated.

Maximum dimensional tolerances are listed below and illustrated by sketches in the Manual for Inspectors of Precast, Prestressed Concrete Products. The dimensions of all members shall be well within these tolerances and the maximum values will be permitted to be approached or equaled only occasionally. Equipment and methods which permit an undue proportion of dimensions approaching the tolerance limits shall not be used. Members having dimensions outside the tolerance limits will be rejected.

In the case of deck beams, it is recognized that the beams individually may comply with the tolerances stated below and still not place satisfactorily in the structure. Final acceptance of the beams, therefore, will be conditioned upon satisfactory placement.

# Maximum Allowable Dimensional Tolerances For Precast, Prestressed Concrete Deck Beams

(mm)

	(
Depth, top slab	± 12
Depth, bottom slab 0 to	+ 12
Depth, overall	. ± 5
Depth (overall from the bottom of the beam to	
the top of the angle when angles are required)	
Width, web	
Width, overall	
Length ± 3 mm per 3 m, Max. + 15 mm to - 20	mm
Square Ends (deviation from square)	. ± 5
Skew Ends (deviation from tangent offset)	
Acute angles equal to or less than 30°	. ± 5
Acute angles greater than 30°	± 12
Beam Seat Bearing Area (variation from plane	
surface when tested with a straightedge)	. ± 2
Horizontal Alignment (deviation from a	
straight line parallel to the centerline	
of beam) $\pm$ 3 mm per 4.5 m, Max.	± 15
Dowel Tubes (spacing between the centers of tube	
and from the centers of tubes to the ends and	
sides of the beams)	± 12
Tie Rod Tubes (spacing from the centers of	
tubes to the ends of the beams)	± 12
Tie Rod Tubes (spacing from centers of tubes to	
the bottom of the beams)	
Total Width of Deck Theoretical width + 15 per	
Maximum Distance Between Beams Measured Below the Keyway	20
Transverse Joints (deviation from specified width)	
Expansion Joints 5 to	+ 15
Fixed Joints 0 to	+ 15

# Precast Concrete Structures

# Maximum Allowable Dimensional Tolerances For Precast, Prestressed Concrete Deck Beams (English)

Inch

Depth, top slab	± 1/2
Depth, bottom slab	0 to + 1/2
Depth, overall	
Depth (overall from the bottom of the beau	am to
the top of the angle when angles are r	equired) ± 1/8
Width, web	± 1/4
Width, overall	± 1/4
Length	$\pm$ 1/8 per 10', Max. + 1/2 to - 3/4
Square Ends (deviation from square)	
Skew Ends (deviation from tangent offse	t)
Acute angles equal to or less than 30°	± 1/4
Acute angles greater than 30°	
Beam Seat Bearing Area (variation from	plane
surface when tested with a straightedg	
Horizontal Alignment (deviation from a	•
straight line parallel to the centerline	
of beam)	$\pm$ 1/8 per 15', Max. $\pm$ 5/8
Dowel Tubes (spacing between the cent	ers of tube
and from the centers of tubes to the e	
sides of the beams)	± 1/2
Tie Rod Tubes (spacing from the centers	
tubes to the ends of the beams)	
Tie Rod Tubes (spacing from centers of	tubes to
the bottom of the beams)	
Total Width of Deck	
Maximum Distance Between Beams Mea	
Transverse Joints (deviation from specifi	
Expansion Joints	
Fixed Joints	

# Maximum Allowable Dimensional Tolerances For Precast, Prestressed Concrete I-Beams and Bulb T-Beams

mm

Depth (flanges, web and fillets) $\pm$ 5
Depth (overall)
Width (flanges and fillets) $\pm 5$
Width (web) + 5 to - 3
Length $\pm$ 3 per 3 m, Max. + 15 to - 20
Square Ends (deviation from square) $\pm 5$
Skew Ends (deviation from tangent offset) $\pm 5$
Side Insert (spacing between centers of inserts
and from the centers of inserts to the ends of the beams) $\pm$ 15
Bearing Plates (spacing between the centers of
bearing plates)
Bearing Plate (spacing between the centers of
bearing plates to the ends of the beams)
Bearing Plate or Bearing Area (variation from a true horizontal plane or from a plane surface
when tested with a straightedge) ± 2
Stirrup Bars (extension above top of the beam)
Stirrup Bars (longitudinal spacing, provided that
there are not less than the required number in
a given length) ± 25
End Stirrup Bars - not more than 50 mm from the end of the beam
Horizontal Alignment (deviation from a straight line parallel
to the centerline of the beam) $\pm$ 3 per 3 m, Max. $\pm$ 30

# Maximum Allowable Dimensional Tolerances For Precast, Prestressed Concrete I-Beams and Bulb T-Beams (English)

Inch

Depth (flanges, web and fillets)	± 1/4
Depth (overall)+	1/4 to - 1/8
Width (flanges and fillets)	± 1/4
Width (web) +	1/4 to - 1/8
Length + 1/8 per 10', Max. +	
Square Ends (deviation from square)	
Skew Ends (deviation from tangent offset)	± 1/4
Side Insert (spacing between centers of inserts	
and from the centers of inserts to the ends of the beams)	± 1/2
Bearing Plates (spacing between the centers of	L 4/0
bearing plates)	± 1/2
Bearing Plate (spacing between the centers of bearing plates to the ends of the beams)	± 1/1
Bearing Plate or Bearing Area (variation from a	± 1/4
true horizontal plane or from a plane surface	
when tested with a straightedge)	+ 1/16
Stirrup Bars (extension above top of the beam)	0 to - 3/8
Stirrup Bars (longitudinal spacing, provided that	0 10 0/0
there are not less than the required number in	
a given length)	± 1
End Stirrup Bars - not more than 2" from the end of the beam	
Horizontal Alignment (deviation from a straight line parallel	
to the centerline of the beam) $\pm$ 1/8 per 10', M	lax. ± 1 1/4

(e) Handling, Storing, Transporting, and Erecting. The handling of precast, prestressed concrete members, from the time of releasing the strands until they are in place in the structure, shall be according to the basic rules specified. Failure to observe these rules may result in damage or destruction of members by the internal stresses. Any member damaged during handling, storing, transporting or erecting shall be replaced by the Contractor at his/her own expense.

The members shall be maintained in upright position at all times and shall be supported only at the ends. During lifting, they shall be supported only by the inserts provided for that purpose. In storage, members shall be supported only at the ends and as specified in the Manual for Inspectors of Precast, Prestressed Concrete Products. During transportation, the ends of I-beams shall not extend a distance of more than the depth of the beam and, in no case, more than 1 m (3 1/2 ft.) beyond the bolsters or other supports on the transporting vehicle. The ends of deck beams shall not extend a distance of more than 1 1/2 times their depth, and in no case more than 1 m (3 ft.), beyond the supports.

During storage, the supports shall maintain the members in essentially a level position and without twisting. Stacking of members in storage will be permitted only with the approval of the Engineer. If such permission is

granted, the supports of all members shall be in the same vertical planes and shall be of adequate thickness to prevent damage to the lifting devices.

Each member shall have proper identification as to number, position in the structure and date of casting painted on its top and on one end. Members shall not be shipped to the jobsite before the 28-day compressive strength data are available except as otherwise specified or approved by the Engineer.

In erecting beams, care shall be taken to keep bridge seats and tops of bearing devices free of foreign materials. Any shifting of beams shall be done while they are held free of the foundation.

Erection of deck beams shall begin at the expansion end or as designated by the Engineer and shall proceed, one beam at a time, across the roadway. During the initial placement of the beams, every effort shall be made by the Contractor to achieve optimum match between beams. The Contractor will be required to shift or interchange beams to achieve a better fit when directed by the Engineer. As the beams are placed in their final position, and prior to securing transverse ties and drilling and grouting dowels, the beams shall be brought to firm even bearing on the seats through the use of the bearing pads and fabric shims furnished with the beams, and/or grinding of the concrete seats as required.

After deck beams are properly placed and firm even bearing assured, the beams, either in pairs for skewed structures or all beams for right angle structures, shall be secured in lateral position by placing and tightening of the transverse tie assemblies. Dowels at the fixed ends of the deck beams shall then be drilled and grout placed and cured and the cast-in-place concrete at the expansion end of the deck beams placed and cured. After this work is completed, the longitudinal keyways between beams shall be filled with an approved non-shrink grout. Prior to grouting, all openings between beam edges at the base of the longitudinal keyways shall be caulked or sealed with a suitable compressible material to prevent leakage of grout. Prior to placement of the grout, the keyways shall be clean and free of all oil, grease, laitance and other foreign substances. The grout shall be mixed and placed according to the grout manufacturer's written instructions or specifications except the use of aggregate in the grout will not be permitted. The minimum grout temperature at the time of placement shall be 10 °C (50 °F.). Rotating drum type concrete mixers will not be allowed for mixing the grout. The keyway surfaces shall be soaked with water for 1 to 2 hours prior to placement of grout. During placement of the grout, the grout mixture shall be worked into the keyway with the trowel blade or with a pencil vibrator. The surface shall be troweled to a smooth finish. The grout shall be cured with wet burlap for a minimum of 3 days. This grout also shall be used for grouting the dowels. The Contractor, at his option, also may use this non-shrink grout for grouting between the ends of the deck beams at fixed piers and for the transverse tie assembly During the curing period, no vehicular traffic, including the Contractor's equipment, will be permitted on the beams. In stage construction with deck beams, stage one shall be constructed as a complete deck. The transverse ties for stage one construction shall not be released during construction of stage two. Threaded sleeves shall be used to secure stage two deck beams to stage one deck and at no time shall the transverse tie nuts for stage one be loosened or removed.

The keyway grout and grout at fixed ends of deck beams will be inspected by the Engineer for cracks. Any cracks found other than shrinkage cracks along the keyway edges shall be sealed at the Contractor's expense with an epoxy bonding compound according to Article 1025.03. The bonding compound shall be applied into the cracks until the cracks are full. The bonding compound shall be a product specifically recommended by the manufacturer, in their printed specifications, for grouting non-moving damp cracks in concrete.

If the cracks are propagating along the keyway from the end of beams, it could indicate the beam or beams are not firmly seated. If this is the case, the Contractor prior to sealing shall check for beam wobble and shim any beams not firmly seated.

# 504.07 Method of Measurement.

- (a) Contract Quantities. The requirements for the use of Contract Quantities shall conform to Article 202.07(a).
- (b) Measured Quantities. Precast concrete bridge slabs and precast, prestressed concrete deck beams will be measured by the square meter (square foot) of horizontal surface area of the individual slabs or beams, as shown on the plans. In determining the total number of square meters (square feet) to be paid for, the overall horizontal surface area of all the slabs or beams specified will be used.

Precast, prestressed concrete I-beams, or Bulb T-beams will be measured by the meter (foot). In determining the total length of beams to be paid for, the specified overall length of the individual beams will be used.

Precast concrete pile caps will be measured for payment in place as each precast concrete cap.

Precast concrete structural members, not specifically mentioned or covered herein, will be measured and paid for as specified in other sections of these specifications, on the plans, or in the Special Provisions.

**504.08 Basis of Payment.** This work will be paid for at the contract unit price per square meter (square foot) for PRECAST CONCRETE BRIDGE SLAB and PRECAST, PRESTRESSED CONCRETE DECK BEAMS of the depth specified, or per meter (foot) for FURNISHING AND ERECTING PRECAST, PRESTRESSED CONCRETE I-BEAMS, or BULB T-BEAMS of the depth specified.

Precast concrete pile caps will be measured and paid for at the contract unit price each for PRECAST CONCRETE CAPS.

# **SECTION 505. STEEL STRUCTURES**

**505.01 Description.** This section shall apply to structures or portions of structures built of structural steel shapes and plates, steel and iron castings, steel

forgings, wrought iron and miscellaneous metals.

The work included under this item shall consist of furnishing, fabricating, transporting, erecting and painting the materials described above, except when limited to only certain portions of the work by the terms of the contract.

**505.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 - Materials:

	Item	Article	/Section
(a)	Structural Steel		1006.04
(b)	Turned and Ribbed Bolts		1006.07
(c)	High-Strength Steel Bolts, Nuts and Washers		1006.08
(d)	Anchor Bolts		1006.09
(e)	Steel Forgings		1006.12
(f)	Steel Castings		
(g)	Gray Iron Castings		1006.14
(h)	Malleable Castings		
(i)	Cast Bronze Plates		1006.21
(j)	Rolled Copper-Alloy Plates		1006.22
(k)	Lead Plates		1006.23
(l)	Paint Materials and Mixed Paints	1008.01 -	1008.23
(m)	Stud Shear Connectors		1006.32
(n)	Nonshrink Grout		1024.01

Structural carbon steel shall be used for all structural shapes, plates and eyebars. Materials for structures that will carry railroad traffic shall be according to AREA Specifications.

#### CONSTRUCTION REQUIREMENTS

**505.03 Drawings.** Before any fabrication is begun, the Contractor shall submit to the Engineer for approval, prints of shop drawings in duplicate. These drawings shall be on sheets 594 mm (24 inches) by 841 mm (36 inches) in size and of adequate quality for microfilming by the Department. All drawings shall be completely titled in accordance with the contract plans and shall pertain to only one structure. Upon approval, the Contractor shall furnish 3 or more prints of the approved drawings, which shall become a part of the original contract and shall be subject to all general or Special Provisions governing it. Changes on approved drawings shall be subject to the approval of the Engineer, and the Engineer shall be supplied with a record of all such changes. The Contractor shall be responsible for the correctness of the drawings, although the drawings may have been approved by the Engineer.

Prints of shop drawings for structures that will carry railroad traffic shall be submitted in triplicate and shall also be subject to the approval of the Railroad Engineer. These drawings shall be reproducible, 594 mm (24 inches) by 841 mm (36 inches) in size, including margins. The margin at the left end shall be 40 mm (1 1/2 inches) and the others 15 mm (1/2 inch) wide. These drawings shall become the property of, and shall be delivered to, the Railroad upon completion of the contract.

During the preparation of shop drawings, the Contractor shall check all general dimensions of the steel work and shall report any discrepancies discovered to the Engineer for revision and correction before fabrication is begun. Allowance will be made to the Contractor for additional material fabricated to correct reported contract

plan errors.

- **505.04 Fabrication.** Structural steel shall be fabricated and stored according to the following requirements, except that for structures carrying railroad traffic, the structural steel shall be fabricated according to the AREA Specifications. Fabrication shall be performed by structural steel fabricators meeting the certification requirements.
  - (a) Workmanship and Finish. The workmanship and finish shall be equal to the best general practice in modern bridge shops. Portions of the work exposed to view shall be finished neatly. Shearing, flame cutting and chipping shall be done neatly and accurately.
  - (b) Storage of Materials. Structural material, either plain or fabricated, shall be stored at the bridge shop above the ground upon platforms, skids or other supports. It shall be kept free from dirt, grease or other foreign matter, and shall be protected as far as practicable from corrosion.
  - (c) Straightening or Curving Material. Rolled material before being laid off or worked shall be straight. If straightening is necessary, it shall be done by methods which will not injure the metal. Sharp kinks and bends may be cause for rejection of the material. Heat straightening of AASHTO M 270 Grade 100 &100W material shall be done only when approved by the Engineer and then only under rigidly controlled procedures.

Rolled beams and welded plate girders that are specified to be horizontally curved shall be curved during fabrication at the fabricating plant.

The Contractor may fabricate welded girders by flame cutting the flanges to the required curvature from rectangular plates prior to fitting and welding to the web, or the Contractor may fabricate welded girders or rolled beams by fabricating a straight unit, and through the application of heat to the flange edges on one side induce the required curvature. Heat-curving will not be permitted on beams or girders fabricated of AASHTO M 270 Grade 100 & 100W steels. Cold bending of beams or girders to the required curvature will be permitted provided the methods and procedures to be used meet with the approval of the Engineer.

When beams or girders are to be heat-curved, the Contractor shall conform to the following requirements:

(1) Type of Heating. Beams or girders may be curved by either continuous or V-type heating. For the continuous method, a strip along the edge of the top and bottom flange shall be heated simultaneously. The strip shall be of sufficient width and temperature to obtain the required curvature. For the V-type heating, the top and bottom flanges shall be heated in truncated triangular areas spaced at regular intervals along each flange. The spacing and temperature shall be as required to obtain the required curvature. The heating shall progress along the top and bottom flange at approximately the same rate. For the V-type heating, the apex of the truncated triangular area applied to the inside flange surface shall terminate just before the juncture of the web and the flange is reached. When the radius of curvature is 300 m (1000 ft.) or more, the apex of the truncated

triangular heating pattern applied to the outside flange surface shall extend to the juncture of the flange and web. When the radius of curvature is less than 300 m (1000 ft.), the apex of the truncated triangular heating pattern applied to the outside flange surface shall extend past the web for a distance equal to 1/8 of the flange or 75 mm (3 inches), whichever is less. Beginning at the truncated end of the heating pattern, heating shall progress slowly toward the base of the pattern spreading with an included angle of 15 to 30 degrees. The base of the heating triangle shall not exceed 250 mm (10 inches) regardless of flange width and thickness. The heating torches shall not begin to progress toward the base of the heating pattern until the truncated end of the pattern is brought up to the specified temperature. Once heating begins to progress towards the base at the pattern, the heating torch(es) shall not be returned to the apex of the heating triangle. Variations in the patterns prescribed above may be made with the approval of the Engineer.

Heating shall be performed using large, approximately 25 mm (1 inch) diameter, multiorifice (rosebud) heating torches manipulated to guard against general and surface overheating. Torches shall use air-propane or air-natural gas unless a specific procedure utilizing other gas mixtures or electric heaters is approved by the Engineer for the girder configuration curved. When heating thick plates, it may be necessary to occasionally interrupt heating for periods of less than one minute to allow the heat to soak into the flange and avoid surface over-heating.

For both types of heating, the flange edges to be heated are those that will be on the inside of the horizontal curve after cooling. Heating both inside and outside flange surfaces is only mandatory when the flange thickness is 30 mm (1 1/4 inches) or greater, in which case, the two surfaces shall be heated concurrently. The maximum temperature shall be as prescribed below. If a chording effect is obtained that is not aesthetically pleasing in the judgment of the Engineer, the Contractor will be required to reheat the member using additional heating patterns as required to obtain the desired results.

Temperature Control. The heat curving operation shall be conducted in such a manner that the temperature of the steel does not exceed 620 °C (1150 °F.). Heating shall be confined to the patterns or areas specified, and shall be applied in such a manner so as to bring the steel within the pattern to the required temperature as rapidly as possible without overheating the steel. Any heating procedure which causes a portion of the steel to be heated to a temperature greater than the 620 °C (1150 °F.) maximum temperature specified will be considered as destructive heating and could be cause for rejection of the member. Steel rejected for overheating may be investigated for reacceptance or repair by tests as directed by the Engineer. The costs of such tests shall be borne by the Contractor. Artificial cooling of the member will not be permitted until the member has cooled to 315 °C (600 °F.). Quenching with water or water and air will not be permitted. Cooling with dry compressed air will be permitted after the steel has cooled to 315 °C (600 °F.). The Contractor shall maintain temperature controls by the use of temperature indicating crayons or other suitable means during the heating and cooling of the member.

- (3) Position for Heating. Members to be heat-curved may be positioned with the web in either a vertical or a horizontal position. When curved in the vertical position, the member must be braced or supported in such a manner that the tendency of the member to deflect laterally during the heat-curving process will not cause the member to overturn. When curved in the horizontal position, the member must be supported near its ends and at intermediate points as required to obtain uniform curvature.
- (4) Sequence of Operations. Members shall be heat-curved in the fabrication plant before they are painted. The heat-curving operation may be conducted either before or after all required welding of transverse intermediate stiffeners is completed. Unless provisions are made for girder shrinkage, connection plates and bearing plates shall be located and attached after heat-curving. If longitudinal stiffeners are required, they shall be heat-curved or flame-cut separately and then welded to the curved girder. When cover plates are to be attached to rolled beams, the beams shall be heat-curved before the cover plates are attached. The cover plates shall be heat-curved or flame-cut separately and then welded to the curved beam.

Girders shall be fabricated to specified cambers by cutting web plates to the required geometries before attaching flanges. Heating may be used for small camber corrections if the method and points of application are approved by the Engineer. The prescribed camber shall be obtained before heat-curving. The Contractor shall make allowance during cambering for any anticipated losses during fabrication and heat-curving. Rolled beams shall not be shop cambered, unless otherwise specified.

Horizontal curvature and vertical camber will not be measured for final acceptance until all welding and heating operations are completed and the flanges have cooled to a uniform temperature. Horizontal curvature will be checked with the beam or girder in a vertical position.

(d) Fastener Holes. All fastener holes shall be either punched or drilled. In all cases, drilling may be substituted for punching of full size holes; subdrilling may be substituted for subpunching; and holes may be drilled from the solid metal instead of being subpunched or subdrilled and reamed provided drilling is done with the material assembled in the same manner as is required for reamed work. Holes punched or drilled full size shall be 2 mm (1/16 inch) larger than the nominal diameter of the fasteners. Subpunched holes for fasteners having diameters greater than 15 mm (5/8 inch) shall be 5 mm (3/16 inch) smaller than the nominal diameter of the Unless otherwise shown, subpunched holes for 20-mm fasteners. (3/4-inch) fasteners shall be 14 mm (9/16 inch) in diameter, and for fasteners having diameters of 15 mm (5/8 inch) or less, the holes shall be punched full size and spear reamed. Subpunched and subdrilled holes shall be reamed to 2 mm (1/16 inch) larger than the nominal diameter of the fasteners.

Where reaming is not required, holes in carbon steel 20-mm (3/4 inch) or less in thickness or in alloy steel 15 mm (5/8 inch) or less in thickness may be punched full size. Holes in material over 20 mm (3/4 inch) thick for carbon steel or over 15 mm (5/8 inch) thick for alloy steel shall be subdrilled and reamed or drilled.

Holes for main truss or arch connections, both shop and field; holes for field connections of skewed portals; and holes for splices of main beams, girders or frames of continuous beam spans, plate girders and rigid frames shall be subpunched and reamed with the members assembled in the shop. This assembly may be made in the horizontal position, except horizontally curved members shall be assembled vertically, unless horizontal assembly is approved by the Engineer. The assembly, including camber, alignment, accuracy of subpunched holes and milled joints shall be approved by the Engineer before reaming is commenced. These requirements shall not apply to holes for field connections of top and bottom chord lateral members, lateral hangers, portal and sway bracing, cross frames and diaphragms. Holes in such secondary members may be punched full size except as otherwise specified.

All holes for end field connections of floor beams, sidewalk brackets and bearing shoes attached to girders shall be subpunched or subdrilled and reamed to a hardened steel template, and all corresponding holes in the members to which they connect shall be reamed to the same template, or these connections may be reamed with the members assembled. Stringer connections to floor beams may be punched full size except as otherwise specified. All steel templates shall have hardened steel bushings in holes accurately located from the centerlines of the connection as inscribed on the template. The centerlines shall be used to accurately locate the template from the milled or scribed ends of the members.

Where shown on the plans, holes for handrail post connections shall be subpunched and shall be reamed during erection after the posts have been aligned.

- (1) Punched Holes. The diameter of the die shall not exceed the diameter of the punch by more than 2 mm (1/16 inch). Holes shall be clean cut, without torn or ragged edges.
- (2) Accuracy of Punched Holes. All punched and subpunched holes shall be punched so accurately that after the steel is assembled and before any reaming is done, a cylindrical pin 3 mm (1/8 inch) smaller in diameter than the nominal size of the punched hole may be entered perpendicular to the face of the member, without drifting, in at least 75 percent of the contiguous holes in the same plane. If this requirement is not fulfilled, the badly punched pieces will be rejected. If any hole will not pass a pin 5 mm (3/16 inch) smaller in diameter than the nominal size of the punched hole, this will be cause for rejection. Drifting to enlarge unfair holes will not be allowed. The Contractor performing the fabrication shall be responsible for the accuracy of all holes, regardless of tolerance in dimensions of rolled sections. If the required accuracy cannot be obtained otherwise, holes for connections shall be subpunched and reamed with the

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members assembled instead of being punched full size.

- (3) Reamed or Drilled Holes. Reamed and drilled holes shall be perpendicular to the face of the member. Drilling shall be done with twist drills and reaming with fluted or adjustable reamers. Where practical, reamers shall be directed by mechanical means, reaming shall be done after the pieces forming a built member are assembled and bolted firmly together. Connecting parts requiring reamed or drilled holes shall be assembled and held securely while being reamed or drilled, and shall be matchmarked. Reamed parts shall not be interchanged. Burrs on all surfaces shall be removed. Unless otherwise approved by the Engineer, assembled parts shall be taken apart for removal of cutting oil, shavings and burrs caused by drilling and reaming.
- (4) Accuracy of Reamed and Drilled Holes. The accuracy of subdrilled holes shall be the same as required for punched holes. Where holes are to be reamed or drilled, 85 percent of the holes in any contiguous group shall, after being reamed or drilled, show no offset greater than 1 mm (1/32 inch) between adjacent thicknesses of metal.
- (e) Connections. All shop and field connections shall be bolted using high-strength steel bolts. Handrail connections to handrail posts and truss members shall be bolted with unfinished bolts.
- (f) Bolts and Bolted Connections. The general requirements for fastener holes shall apply for bolt holes. Bolts shall have hexagonal heads and nuts.
  - (1) Unfinished Bolts. Where unfinished bolts are permitted, the bolts shall be machine bolts. Bolts transmitting shear shall be threaded to such a length that not more than one thread will be within the grip of the metal. The bolts shall be of a length to extend entirely through the nuts but not more than 5 mm (1/4 inch) beyond them. One lock washer shall be placed under the nut of each bolt connecting handrails, and one cut washer shall be provided over each slotted hole, otherwise washers will not be required.
  - (2) Turned Bolts. Turned bolts shall be finished by a finishing cut. Holes for turned bolts shall be carefully reamed or drilled 1 mm (1/32 inch) larger in diameter than the bolt. The threads of each turned bolt shall be entirely outside the grip of the metal. A washer 5 mm (1/4 inch) thick shall be used under each nut.
  - (3) High-Strength Steel Bolts. Bolted parts shall fit solidly together when assembled. Contact surfaces, including those adjacent to bolt heads, nuts or washers, shall be free of all mill scale, dirt, burrs and other defects that would prevent solid seating of all parts.

Methods of installation and tightening shall conform to the Specification for Structural Joints Using ASTM A 325M (A 325) or A 490M (A 490) Bolts, for slip-critical connections as issued by the Research Council on Structural Connections Joints of the Engineering Foundation, except as follows.

To insure solid seating of all parts of a slip-critical connection, no

visible gap shall remain between the faying surface when bolts are initially tightened to the snug tight condition [approximately 45 kN (10,000 lbs.)].

All high-strength bolts shall have a hardened washer under the element (nut or bolt head) turned in tightening regardless of the method used in tightening.

Inspection will be according to the requirements of the latest issue of the Specifications for Structural Joints using ASTM A 325M (A 325) or A 490M (A 490) bolts for slip-critical connections. The Contractor shall provide at his/her own expense a calibration device capable of indicating bolt tension. The calibration device shall be capable of testing the shortest bolt length encountered on the structure down to the following minimum lengths:

50 mm (2 inches) for M16 and M20 (5/8 inch and 3/4 inch) diameter bolts

60 mm (2.25 inches) for M22 (7/8 inch) diameter bolts

65 mm (2.5 inches) for M26 (1 inch) diameter bolts



The Contractor shall also furnish at his/her own expense an inspection torque wrench for use by the Engineer.

(g) Shop Assembling. Surfaces of metal which will be in contact after assembling shall be carefully cleaned. The parts of a member shall be assembled, well pinned and firmly drawn together with bolts before reaming or tightening of fasteners is commenced. The member shall be free from twists, bends and other deformations that would prevent the solid seating required under Article 505.04(f)(3). A 1.5 mm (1/16 inch) or greater difference in plate thickness or member depths across a bolted splice shall be rectified with shims included during reaming, matchmarked and shipped with the member. Preparatory to the tightening of fasteners of material punched full size, the holes, if necessary, shall be reamed for the admission of the fasteners.

Parts not completely fastened in the shop shall be secured by bolts insofar as practicable to prevent damage in shipment and handling. Members assembled in the shop for reaming of field connections shall remain assembled until shop inspection by the Department has been made.

- (h) Drifting of Holes. The drifting done during assembling shall be only such as to bring the parts into position, and not sufficient to enlarge the holes or distort the metal.
- (i) Match marking. All connecting parts of members having reamed connections shall be match marked while completely assembled at the fabricating plant, and 3 or more prints of a diagram showing such marks shall be furnished to the Engineer.
- Stamping of Members for Identification. Any metal die stamping of steel members shall be done using low stress dies. Low stress dies are those

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manufactured to produce impressions that are rounded on the bottom rather than sharp edged. Letters and numbers shall be 10 mm (3/8 inch) to 15 mm (1/2 inch). When used, the dies shall be lightly struck to produce the minimum impression that can be clearly seen in the absence of paint and mill scale.

(k) Flame Cutting. Structural steel or wrought iron may be flame cut, provided a smooth surface free from cracks and notches is secured and provided that an accurate profile is secured by the use of a mechanical guide. Hand cutting shall be done only where approved by the Engineer.

In all flame cutting, the cutting flame shall be so adjusted and manipulated as to avoid cutting beyond (inside) the prescribed lines. Flame cut surfaces shall meet the ANSI surface roughness rating value of 1000 for material up to 200 mm (8 inches) thick, except that flame cut surfaces of members not subject to calculated stress shall meet the surface roughness value of 2000.

Flame cut surfaces of members carrying calculated stress or to be painted shall have their corners rounded to 2 mm (1/16 inch) radius by grinding after flame cutting.

Reentrant cuts shall be filleted to a radius of not less than 20 mm (3/4 inch).

Surface roughness, exceeding the above values, and occasional gouges not more than 5 mm (3/16 inch) deep on otherwise satisfactory flame cut surfaces, shall be removed by machining or grinding. Corrections of the defects must be faired with the surface of the cut on a bevel of 1 to 10 or less. Occasional gouges of flame cut edges of material, other than AASHTO M 270 Grade 100 & 100W more than 5 mm (3/16 inch) deep but less than 11 mm (7/16 inch) for material up to 100 mm (4 inches) thick, and less than 15 mm (5/8 inch) for material more than 100 mm (4 inches) may be repaired by welding. Welding shall be done with a repair procedure approved by the Engineer as appropriate for the thickness being repaired. The completed weld shall be ground smooth and flush with the adjacent surface.

- (I) Finishing. Finished members shall satisfy tolerances for workmanship and dimensionality.
  - (1) Edge Planing. Where edge planing is required, sheared edges or ends shall be planed to a depth of not less than 3 mm (1/8 inch). Sheared edges of material more than 15 mm (5/8 inch) thick and carrying calculated stress shall be planed to a depth of 6 mm (1/4 inch). Sheared edges of material up to 15 mm (5/8 inch) thick which carry calculated stress shall be planed unless enclosed by welds.
  - (2) Facing of Bearing Surfaces. The top and bottom surfaces of steel slabs and base plates shall be planed, or else the slabs and base plates shall be hot straightened. Cap plates of columns and pedestals shall be planed. Sole plates of beams and girders shall be planed or hot straightened and shall have full contact with the beam or girder flanges. Cast pedestals shall be planed on surfaces that are to be in contact with steel, and shall be rough finished on surfaces that are to

be in contact with masonry or lead masonry plates. Surfaces of bronze or copper-alloy bearing plates for sliding contact shall be finished. In finishing the surfaces of expansion bearings, the cut of the tool shall be in the direction of the expansion.

The surface finish of bearing and base plates and other bearing surfaces that are to come in contact with each other or with concrete shall meet ANSI surface roughness requirements as defined in ANSI B 46.1, Surface Roughness, Waviness and Lay, Part 1:

Steel slabs	ANSI 2,000
Heavy plates in contact in shoes to be welded	ANSI 1,000
Milled ends of compression members, milled or	
ground ends of stiffeners and fillers	ANSI 500
Bridge rollers and rockers	ANSI 250
Pin holes	ANSI 125
Sliding bearings	ANSI 125

Bronze or copper-alloy bearing plates shall be self-lubricating plates having special graphited and metallic inserts to provide maximum lubrication. The manufacturer's methods for producing the bearing plate shall meet with approval of the Engineer. The plates shall be provided with recesses (not grooves), which shall not extend through the plates, but which shall be filled with a lubricating compound capable of withstanding the atmospheric elements and consisting of graphite and metallic substances with a lubricating binder. Shellac or other non-lubricating binder shall not be used. The compound shall be pressed into the recesses by hydraulic presses so as to form dense non-plastic lubricating inserts. The lubricating area shall comprise not less than 25 percent and not more than 30 percent of the total area. The plates shall not be finished after the lubricating compound has been pressed into place. The coefficient of friction shall not exceed 1/10 at 14 MPa (2000 psi).

Rockers shall have smooth bearing surfaces which have been turned in a lathe to a uniform radius.

- (3) Abutting Joints. Abutting joints in compression members shall be faced and brought to an even bearing. Abutting joints in tension members and at beam or girder splices need not be faced but the openings shall be not less than 2 mm (1/16 inch) nor more than 5 mm (1/4 inch) at any point.
- (4) End Connection Angles. End connection angles of floor beams and stringers shall be flush with each other and accurately set as to position and length of member. Backs of connection angles on floor beams shall be milled to exact length of member. The connection angles shall be fitted with such accuracy that the milling will not reduce their thickness by more than 3 mm (1/8 inch) at any point.
- (5) Edge Grinding. All outside corners remaining after shop fabrication shall be uniform, free of abrupt irregularities and dull to the touch. Fins, burrs, cutting slag, deformities, minor gouges, sharpness (corner more acute than a 2 mm (1/16 inch) radius), and other hazards to

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handling or impediments to proper coating application and performance shall be corrected by grinding and/or blasting. If painting is required, anomalies shall be corrected before blasting.

(6) Fit of Stiffeners. For bolted construction, end stiffener angles of girders and stiffener angles intended as supports for concentrated loads shall be milled or ground to secure an even bearing against the flange angles or beam flanges. Welding, in lieu of milling or grinding, will not be permitted at tension flanges. Intermediate stiffener angles shall be cut to allow a space of 5 mm to 10 mm (1/4 to 3/8 inch) between the ends of the outstanding leg and the tension flange. Fillers under stiffeners shall fit within 3 mm (1/8 inch) at each end.

For welded construction, bearing stiffeners shall be milled to bear at the bearing ends and a tight fit provided at the other ends. Intermediate stiffeners shall be welded at the compression flange, and as specified on the plans at the tension flange.

- (7) Visual Inspection and Repair of Plate Cut Edges. Discontinuities discovered in plate cut edges by visual inspection shall be repaired according to Article 505.04(k) and ANSI/AASHTO/AWS D1.5/BWC.
- (m) Links. Links for pin and link assemblies or bearings experiencing uplift shall be fabricated from rolled plate. The material shall have a toughness requirement of 48 J (35 ft. lbs.) at -7 °C (20 °F.) Charpy V-Notch impact energy. Yield strength of the link material shall not exceed 480 Mpa (70 ksi). The links shall be straight and parallel or otherwise machined to bring them within contract tolerances. Holes in links for pins and bushings shall have a maximum roughness equivalent to a 0.8 micrometer (32 microinch) finish.
- (n) Rollers and Pins. Rollers and pins shall be straight, smooth, and free from surface flaws. They shall be accurately turned to the dimensions shown on the drawings and the final surface shall be produced by a finishing cut, except expansion rollers of cold finished steel bars having a smooth, true surface, need not be turned. Pins for pin and link assembly bars shall have a ground finish 0.8 micrometers (32 microinch) minimum. Pins shall be ground to a smooth finish and surfaces shall be 100 percent inspected by magnetic particle or dye penetrant testing after grinding. Any cracks or other flaws detected shall be reported to the Engineer and will be cause for rejection. After testing, carbon steel pins shall be coated with grease for corrosion protection.
- (o) Boring Pin Holes. Pin holes shall be bored true to the specified diameter, smooth and straight, at right angles with the axis of the member and parallel to each other unless otherwise required. The final surface shall be produced by a finishing cut. The actual distance from center to center of pins at link connections shall not vary from that specified by more than 1 mm (1/32 inch). The boring shall be done after the member is welded or shop bolted. If metallic pin bushings are required, they shall be shrunk fit and their internal diameters shall be ground to 0.8 micrometer (32 microinch) minimum finish.
- (p) Pin Clearances. The fit between a hole bored into a structural member and

a pin shaft shall be according to ANSI Standard B4, Class RC8, loose running fit. For pins bearing on metallic shrink fit bushings, the fit shall be ANSI B4, Class RC7. For pins bearing on Teflon Impregnated fiber reinforced bushings, the bushing manufacturer's recommended tolerances for fit shall be followed for the hole and pin diameters. Tolerances for all pin diameters and pin holes shall satisfy the following:

Nominal Pin Diameter	Range of Clearance	Tolerances from Nominal Sizes	
		Hole	Pin
mm	μm	μm	μm
50-80	152-343	<u>+114</u> 0	<u>-152</u> -229
80-120	178-394	<u>+127</u> 0	<u>-178</u> -267
120-180	203-457	<u>+152</u> 0	<u>-203</u> -305
180-250	254-546	<u>+178</u> 0	<u>-254</u> -368
250-315	305-635	<u>+203</u> 0	<u>-305</u> -432
315-400	356-737	<u>+229</u> 0	<u>-356</u> -508

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Nominal Pin	Range of	Tolerances from Nominal Sizes	
Diameter	Clearance		
		Hole	Pin
(inches)	(inch x 10 <sup>-3</sup> )	(inch x 10 <sup>-3</sup> )	(inch x 10 <sup>-3</sup> )
1.97-3.15	6.0-13.5	<u>+4.5</u> 0	<u>- 6.0</u> - 9.0
3.15-4.73	7.0-15.5	<u>+5.0</u> 0	<u>- 7.0</u> - 10.5
4.73-7.09	8.0-18.0	<u>+6.0</u> 0	<u>- 8.0</u> -12.0
7.09-9.85	10.0-21.5	<u>+7.0</u> 0	<u>- 10.0</u> - 14.5
9.85-12.41	12.0-25.0	<u>+8.0</u> 0	<u>- 12.0</u> - 17.0
12.41-15.75	14.0-29.0	<u>+9.0</u> 0	<u>- 14.0</u> - 20.0

- (q) Welding. Welding shall be according to the requirements of the ANSI/AASHTO/AWS D 1.5 BWC Specifications, except steel tubular structures shall be covered by AWS D1.1. Welding of steel shall not be done except to remedy minor defects or with the approval of the Engineer. Welding shall be done with shielded metal arc, submerged arc, or flux cored arc unless otherwise authorized by the Engineer.
  - Modifications to the Code. The following modifications to the specified sections of BWC shall apply.
    - a. In sections 4 and 5 of the BWC, including tables 4.1, 4.2, 4.3 and 4.4, the base metals shown in each row of the following list shall be considered equivalent for the purposes of fabrication and weld procedure qualifications:

Row	<u>ASTM</u>		AASH	HTO OTH
1	A 36M	A 709M Gr. 250	M 183M	M 270M Gr. 250
2	A 572M Gr. 345	A 709M Gr. 345	M 223M Gr. 345	M 270M Gr. 345
3	A 588M	A 709M Gr. 345W	M 222M	M 270M Gr. 345W
4	A 852M	A 709M Gr. 480W	M 313M	M 270M Gr. 480W
5	A 514M	A 709M Gr. 690W		M 270M Gr. 690W
6	A 517M	A 709M Gr. 690	M 244M	M 270M Gr. 690

## (English)

Row	ASTM AASHTO			
11000	<u> </u>		70.0	1110
1	A 36	A 709 Gr. 36	M 183	M 270 Gr. 36
2	A 527 Gr. 50	A 709 Gr. 50	M 223 Gr. 50	M 270 Gr. 50
3	A 588	A 709 Gr. 50W	M 222	M 270 Gr. 50W
4	A 852	A 709 Gr. 70W	M 313	M 270 Gr. 70W
5	A 514	A 709 Gr. 100W		M 270 100W
6	A 517	A 709 Gr. 100	M 244	M270 Gr. 100

Charpy-V-notch (CVN) Testing: "M270 M Gr. XXT" (M270M Gr. XXT) shall satisfy non-Fracture Critical Material requirements "M270 M Gr. XXX F" (M270 Gr. XXF) shall satisfy Fracture Critical Material (FCM) requirements: "M270 M Gr. XX" (M270 Gr. XX) and all other material designations shall be tested

according to the contract. All CVN testing shall be for Zone 2.

- In Section 5 of the BWC, 5.2 requires the Contractor to perform b. Qualification or Verification testing. The Department will consider each fabrication organization as a separate Contractor for this requirement of the BWC. For fabricators operating in multiple locations, either with a group of buildings or at geographically separated facilities, weld procedures for the same type of equipment, used under similar operating conditions may be based on a common set of Procedure Qualification Reports (PQRs). If routine nondestructive testing reveals significant disparities in production quality that may be attributed to equipment variation then separate qualification tests shall be done at each location or machine involved. Non-FCM PQRs based on qualification tests, pretests and/or verification tests shall remain valid as long as no significant changes occur in electrode/flux components or properties, subject to evidence of the shop's successful use of the process on equal or greater strength material at least every 6 If more than 6 months elapse without documented months. successful use of the process, the Engineer may require regualification of the PQR used to prepare the WPS proposed. Evidence of satisfactory use shall include Fracture Critical procedure tests, nondestructive examination of production welds, or welder/weld operator qualification tests. The Engineer will accept evidence of prior testing provided the PQR is complete and shows compliance with these specifications.
- (2) Electrodes and Flux. Welding electrodes and flux for submerged arc welding shall bear the manufacturer's marking showing the material to be of the proper class. The equipment and the combination of rod and flux to be used shall be submitted to the Engineer for approval, together with evidence of the manufacturer's PQR and the Contractor's verification test(s) or the Contractor's PQR except as exempted.

For flux cored electrodes, only E7XT-6 or E7XT-8 may be used in areas susceptible to drafts or wind exceeding 8 km/h (5 mph). Other flux cored electrodes utilizing gas shielding and satisfying the BWC may be used in enclosed, protected environments with air movement of less than 8 km/h (5 mph). Welds made with E7XT-6 or E7XT-8 shall not be covered by or incorporated into welds made with other electrodes.

Ancillary products described by subparagraph 1.3.6 of the BWC shall include: cross frames and diaphragms for non-curved structures and not designed to convey liveload stresses, finger plate assemblies, pedestals and bolsters, retainer angles, walkway grating, and other items specifically identified by the Engineer.

Electrodes and flux used for welding tubular structures and which satisfy prequalification requirements in the AWS D1.1 shall not require qualification testing.

When PQR, Pretests, and/or Verification Tests are not required,

variables affecting heat input shall be within ranges specified by consumable manufacturers, and supported by manufactures' compliance reports not more than 12 months old which shall be in a file maintained by the Contractor and furnished to the Engineer or Inspector upon request. Any parameters (gas-flow, current limits, E.S.O., polarity, etc.) not within the manufacturers guidelines shall require qualification testing for the WPS.

The Inspector and Contractor's QC shall ensure the Procedure Qualification Test weld parameter variables are being accurately monitored and recorded for each pass, and that specimen identity is constantly maintained. Similarly, the Inspector and QC shall assure the critical weld parameters (preheat, travel speed, wire feed speed, current, etc.), consumable condition and weld quality are adequately monitored throughout production.

When repetitive welding deficiencies persist even after adjustments are made, the Inspector shall have authority to prohibit use of the Weld Procedure Specification (WPS), consumables involved, welding equipment and/or welding personnel, as applicable, for Department projects until anomalies are corrected to the Inspector's satisfaction. Such deficiencies may include: lack of tie-in or penetration; overlap; large or frequent slag inclusions; poor deslagging and interpass cleaning; ropiness, convexity or concavity of bead; gross porosity; and non-uniform weld size. If more serious deficiencies are noted, such as weld or underbead cracking, extensive lack of fusion, wet flux, contaminated weld zone or not conforming to an approved WPS, the Inspector may require either removal of questionable welds or additional NDT at the Contractor's expense. If deficiencies are attributable to the WPS or a specific electrode-flux combination, the Engineer will have authority to require the Contractor to either repeat Qualification Testing or to use another approved WPSs.

(3) Procedures. Complete Weld Procedure Specifications (WPSs) shall be submitted to the Engineer with fully documented and accepted PQRs (if applicable) for approval. The WPS submitted may be either generic for common situations on multiple projects or be tailored to suit the particular fabrication project.

The WPS shall include the following items: general instructions for fit-up, techniques and welding sequences; types of steel; joint description and preparation; welding position; polarity, amperage, voltage and linear welding speed; electrode size and type, flux designation and consumable manufacturer's trade name(s); number of passes, maximum width and thickness of weld layers, and any procedure change between passes in the same weld; preheatinterpass temperatures, maximum and minimum; post heat temperature and duration; and other data necessary to fully describe the welding procedure.

(4) Welder Qualification. All welders, welding operators, and tackers shall be qualified by test according to the applicable welding code, at the Contractors' expense. The Engineer may accept evidence of previous qualification for welders under the applicable welding specifications.

(5) Fabrication. Shop welded splices shall be complete penetration, providing the full strength of the section. Additional shop splices required by limiting lengths of material may be used if they are detailed for the full strength of the member and are placed at locations approved by the Engineer.

Flange-to-web welds and shop welded splices in flanges or webs shall use the automatic submerged arc welding process. All flange-to-web fillet welds exceeding 8 mm (5/16 inch) shall be made in the flat position.

All fillet welding of stiffeners to webs shall be done by the automatic submerged arc method unless otherwise approved by the Engineer. If the applicable code permits welding on areas with tight mill scale present, WPSs utilizing consumables with sufficient deoxidizing capacity shall be employed to avoid porosity or lack of fusion. Ends of welds shall have full throat, no unfilled craters and shall terminate approximately 5 mm (1/4 inch) from the stiffener snip or end. Tack welds shall start a minimum of 75 mm (3 inches) from the end and shall be a minimum 40 mm (1 1/2 inches) long.

The components to be welded shall be securely held in position without excessive restraint that could result in shrinkage cracks or lamellar tearing. The sequence of welding shall minimize distortion and warpage in the weldment. Special precautions shall be taken when welding during cold weather to avoid extreme thermal gradients within the zone of welding influence and to avoid adversely effecting the manual functions of the welder or welding operator. In certain cases, the BWC minimum preheat and interpass temperatures may be insufficient for steels with nominal yield strengths exceeding 350 MPa (50 ksi) and thicknesses above 20 mm (3/4 inch). Preheat for these steels shall be calculated if the nominal welding electrode strength exceeds 550 MPa (80 ksi) and the plate sulfur content exceeds 0.01%, or if either plate's carbon equivalent exceed 0.4%. Preheat in the vicinity of the arc, shall be maintained according to the BWC.

Tolerances for welded components shall be according to the BWC except: the combined warpage and tilt of the bottom flange on welded I-shaped facia (exterior) girders shall not exceed 1/200 of the total flange width or 3 mm (1/8 inch), whichever is greater, except as specified by the BWC for bearing locations and where abutting parts are butt welded; the maximum deviation (+ or -) from specified camber for a span or girder segment (abutment-to-splice or splice-to-splice) shall be 1 mm (1/32 inch) X number of meters (feet) of total length divided by 3 m (10 ft.) or 12 mm (1/2 inch), whichever is greater, but in no case shall exceed 20 mm (3/4 inch).

Shop butt welds in flanges and webs shall be completed, tested, and accepted before the flanges are assembled on the web. Extension

blocks (run-on/run-off tabs) matching the joints cross section are to be used for all butt welds, and for flange-to-web fillet welds. In lieu of extension blocks for fillet welds, additional length of material may be provided to ensure quality welds for the full length of the finished member. Extension blocks shall be removed upon completion of the weld and the ends of the weld ground flush according to the BWC.

(6) Inspection. The inspection of welds and workmanship will be performed according to the BWC except as modified.

Prior to the start of fabrication of their first project for the Department within the previous 24 months, the Contractor's QC and production supervisors and the Engineer shall have a conference to ensure agreement regarding the details of the standard shop procedures, advance notifications to the Inspector, specific items for QC/QA acceptance, material documentation, cleaning and painting requirements, the sequence of fabrication to be followed, the status of qualifications for welders and welding operators, and approval of electrodes, wire, flux, other welding materials and equipment.

The welding and testing of all specimens for qualification of procedures, welder, tacker and/or welding operators shall be witnessed by personnel from two separate agencies, independent of the fabricator and acceptable to the Engineer. These may include the Inspector, Inspectors from other State DOTs, and/or qualified individuals from independent testing agencies which meet the approval of the Engineer. Qualifying semiautomatic and manual welders, welding machine operators, and welding procedures shall be at the expense of the Contractor.

In addition to visual inspection of all welds, radiographic, ultrasonic, and magnetic particle inspection will be required. The mandated radiographic, ultrasonic, and magnetic particle inspection shall be performed by the Contractor and the cost shall be included in the price If the Engineer directs additional testing bid for structural steel. specified and this testing detects nonconformance, the Contractor shall repair and retest at the Contractor's expense. Where no rejectable defects are found in portions of additional areas tested at the Engineer's direction, then the cost of testing those portions will be at the Department's expense.

When radiographic, ultrasonic, and magnetic particle inspection is specified, the equipment, process and weld surface preparation shall be according to the BWC. Personnel performing nondestructive testing shall be qualified according to the American Society for Nondestructive Testing (ASNT) Recommended Practice No. SNT-TC-1A and the applicable Supplement A, B, or C. Only individuals qualified for NDT Level I, working under the direct supervision of an individual qualified for NDT Level III or individuals qualified for NDT Level III or NDT Level III may perform nondestructive testing. The Engineer may either require qualification of personnel or accept documented evidence of previous qualification.

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All butt welds in flanges and webs shall be radiographically inspected. In addition, butt welds in which the thickness of the thinner plate equals or exceeds 75 mm (3 inches) shall also be ultrasonically inspected. All joints to be inspected shall be free of paint, scale, and grease, and shall be ground flush on both sides. The direction of grinding shall be perpendicular to the length of the weld. All runoff plates or other appendages appearing in the radiograph, shall be completely removed before inspection.

All radiographs shall be taken and interpreted by qualified technicians acceptable to the Engineer. The original film and a complete report describing the procedure and the technician's interpretation, properly identified as to piece and location of the weld, shall be submitted to the Inspector for approval prior to acceptance of the weld. The Contractor shall provide a satisfactory viewer and an area to view the radiographic film. If the original film is found to be unacceptable for review, by the Inspector, another radiograph of the joint shall be taken by the Contractor at no additional cost to the Department. The film type shall be identical. In the event the Contractor questions the Inspector's interpretation of the radiographic films, a joint review of the film will be made. The Engineer's final interpretation shall govern.

The double film technique shall be used and one set shall become the property of the Department. The film shall be fine grain and shall be 115 mm (4 1/2 inches) by 430 mm (17 inches). When areas to be radiographed are too large for one film, individual exposures shall be made for each film used. The limits for one film shall be 375 mm (15 inches) for web shots and 400 mm (16 inches) for flange shots except for flanges 30 mm (1 1/4 inches) and thicker the limits shall be 375 mm (15 inches). Either X-ray or gamma rays may be used to produce the radiograph. Double screens shall be used and may be either pure lead or antimony lead with a maximum of 6% antimony. Tin coated lead foil or fluorescent screens shall not be used. radiographing, butt welds thicker than 12 mm (1/2 inch) the Contractor shall place steel edge blocks of radiographically clean material and maximum ANSI roughness less than 3 μm (125 micro inch) in tight contact, maximum gap less than 2 mm (1/16 inch), along side each edge of the weldment. The thickness of the blocks shall not be less than the joint thickness and length shall equal or exceed 115 mm (4 1/2 inches) to cover the film. The cost of furnishing and placing the blocks for radiographing will be included in the cost of the structural steel. At tapered or radiused width transitions, the narrower width may be extended up to 75 mm (3 inches) beyond the weld centerline to allow use of straight edge blocks.

If radiographic inspections disclose rejectable defects, they shall be repaired and additional radiographs shall be taken for each repaired weld, at the expense of the Contractor, and submitted to the Inspector for approval.

All radiographs shall be positively and properly identified by the Contractor in a manner approved by the Engineer. The Contractor shall furnish the Engineer a 594 x 841 mm (24 x 36 inch) drawing with

the weld identification and showing assembly of the steel into final members or pieces. Identification lettering of radiographs shall be placed on the source side along with the penetrameters. Lettering on radiographs of repairs shall show an "R" and the number of the repair shot. This additional identification shall be placed next to the film number.

Location marks shall be stamped in the steel by the Contractor prior to radiographing, using a prick punch with a dull tip. These will be located by lead arrows, but only the "floating" mark shall be visible on the film. The location marks shall consist of center punch marks 40 mm (1 1/2 inches) from the center of the weld for plates up to 75 mm (3 inches) thick or 50 mm (2 inches) from the center on thicker plates, and 60 mm (2 1/4 inches) in from each edge of the plate. In addition, there shall be one randomly placed, "floating" punch mark within each exposure at the same distance from the center. The punch marks shall be placed in the thinner plate. In a series of overlapping exposures, the location marks shall be placed at approximately every 375 mm (15 inches).

All complete penetration tee and corner joints of primary stressed members shall be ultrasonically inspected. Joints of secondary members shall be ultrasonically inspected as identified in the contract. Complete penetration tee and corner joints in compression members shall have at least 300 mm (1 ft.) of every 1.2 m (4 ft.) 300 mm (1 ft.) of each joint less than 1.2 m (4 ft.) ultrasonically inspected. If unacceptable defects are found in any test length, the full length of the weld or 900 mm (3 ft.) either side of the test length shall be ultrasonically inspected. If unacceptable defects are found in more than 20 percent of the 300 mm (1 ft.) increment lengths tested, the full length of the joint shall be ultrasonically inspected. penetration tee and corner joints in members subject to tension or stress reversal shall be ultrasonically inspected the full length of the joint. Welds within 300 mm (1 ft.) of repairs shall be retested after the repairs are made.

Magnetic particle inspection will be required of each fillet weld on nonfracture critical girders, floor beams, stringers and truss members, and for root and final passes of partial penetration groove welds in primary members unless specifically exempted by the Engineer. At least 300 mm (1 ft.) of every 3 m (10 ft.) of weld length or 300 mm (1 ft.) of each weld less than 3 m (10 ft.) in length, plus welds within 300 mm (1 ft.) of all starts and stops shall be tested, except bearing assembly to flange and seat angle to web welds shall only be tested when visual inspection indicates possible flaws. The test shall be located at random in the members so as to be typical of the welding. Random locations are subject to selection by the Engineer. If unacceptable defects are found in any test length of a fillet weld, the full length of the weld, or 1.5 m (5 ft.) on either side of the test length, which ever is lesser, shall be magnetic particle tested.

For Fracture Critical Members (FCM), fillet welds on flanges and webs that may be in tension areas shall receive 100 percent magnetic

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particle inspection.

The magnetic particle inspection procedure and techniques shall be according to ASTM E 709 and shall be done in the presence of the Engineer. The Engineer will examine the magnetic particle tests and give approval before the members will be accepted. Welds within 300 mm (1 ft.) of repairs shall be retested after the repairs are made.

Welded or cast steel bearing assemblies weighing more than 160 kg (350 lbs.) each shall be nondestructively examined by visual magnetic particle and/or ultrasonic methods, as directed by the Engineer to insure no critical flaws exist.

Welds shall have no cracks nor incomplete fusion or lack of penetration, and regardless of the method of inspection, shall have no other defects exceeding the limits of size or frequency of occurrence specified. Fusion defect signifies slag inclusions and similar generally elongated defects.

Surface porosity in all welds shall not exceed 5 mm (3/16 inch) in 25 mm (1 inch) of weld nor 10 mm (3/8 inch) in 300 mm (1 ft.) of weld. Cluster porosity size shall be determined by describing a circle around the cluster of holes. If the circle diameter is 5 mm (3/16 inch) or greater, the porosity must be ground out and rewelded. For linear porosity, a line connecting 3 or more adjacent pores shall be drawn. Adjacent pores are defined as pores separated by less than 5 mm (1/4 inch). If the line drawn exceeds 10 mm (3/8 inch) in 300 mm (1 ft.), the porosity shall be ground out and rewelded. The maximum diameter for a single pore shall not exceed 2 mm (3/32 inch). The maximum frequency shall not exceed 1 porosity episode in 100 mm (4 inches) nor 5 (6) episodes for every 1 m (4 ft.) of weld. The above criteria shall also apply to all subsurface welds which are critical or heavily stressed welds that are subjected to various nondestructive tests.

The Contractor shall give the Engineer sufficient advance notice of the date on which the material will be radiographic, ultrasonic or magnetic particle inspected so that the Engineer may be present during the inspection.

(r) Bent and Welded Material. Material for details and splices, other than stiffener angles, that must be heated before being bent, shall be bent at a temperature not higher than required to produce a cherry-red color. After being bent, the whole piece shall be heated again to a cherry-red color and annealed. If the bend is made by cutting and welding, the whole piece shall be heated to a cherry-red color after being welded, and shall be annealed.

Stress-relief annealing shall be accomplished by heating the bent area of the piece in a portable or static furnace at a rate not to exceed 37 °C per hour (100 °F. per hour), and holding between 565 °C-620 °C (1050 °F.-1150 °F.) for 1 hr. per 25 mm (1 hr. per inch) of section, and slowly cooling at a maximum rate of 37 °C per hour (100 °F. per hour). The field bending of AASHTO M 270 Grades 100 or 100W is not

- permitted. Forming of AASHTO M 270 Grades 100 or 100W shall be accomplished only by forging techniques, as approved by the Engineer.
- (s) Fillers. When wide flange beam sections are used for truss members, fillers may be required at the panel point connections due either to the variation in depth of a given section or to the use of different sections intersecting at a panel point. Where fillers are shown on the plans at such connections, the specified thickness is the theoretical thickness required and during fabrication the thickness of such fillers shall be adjusted to the actual clearances as determined by measurements on the members involved. Such fillers shall be secured with high-strength steel bolts or welded to the main material as shown on the plans. Fillers shall not be welded to tension members or members carrying design bending moments.

Slight inaccuracies in the depths of rolled sections at a given panel point may be corrected by the use of thin fillers not shown on the plans. Such thin fillers shall not be tack welded to the member.

- (t) Screw Threads. Threads for all bolts and pins for structural steel construction shall conform to the Unified Standard Series UNC-ANSI B 1.1, Class 2A for external threads and Class 2B for internal threads, except pin ends having a diameter of 35 mm (1 3/8 inches) or more shall be threaded 6 threads to the 25 mm (1 inch).
- (u) Anchor Bolts. Masonry anchor bolts shall be of the type and of the diameter shown on the plans, or as approved by the Engineer, with hexagonal nuts. They shall be galvanized.
- (v) Errors in Fabrication. When the fabrication and erection are performed under different contracts, the Contractor performing the fabrication shall be responsible for all errors in fabrication.
- **505.05 Inspection.** All material and workmanship shall be subject to inspection by the Engineer. The cost of inspection, both at mill and shop, will be borne by the Department, except whenever any inspection is conducted outside the Continental United States, the Contractor shall bear all costs of travel and subsistence of the Department's inspectors on an actual cost basis.
  - (a) Shop Inspection. The Contractor shall give the Engineer ample notice of the beginning of work in the shop. No work shall be done before the Engineer has been notified. The Contractor shall lay out and arrange the individual members or units to be inspected so that erection marks on each may be readily distinguished and so that each member or unit is accessible for such measurements as the Inspector may deem necessary. If the material has not been inspected at the mill before being delivered to the fabricating shop, the Contractor shall assist the Inspector by turning the steel to permit examination on all sides. Prior to shop inspection by the Engineer, the Contractor shall furnish the Engineer with a list of all main stress carrying material properly identified with the piece mark and heat number. The heat number, as established by the rolling mill, shall be preserved through the fabrication process for identification of the material by the Engineer. If during the fabrication, the original number is hidden, cut off or otherwise obliterated, the Contractor shall replace the number on the material in a conspicuous location.

- (b) Shop Assembly. All trusses and arches, whether reamed or punched, shall be assembled at the fabricating plant, unless otherwise noted. All steel structures having reamed field connections shall be assembled, unless otherwise noted, before reaming is commenced. Assembled steel structures shall not be knocked down until after shop inspection has been made.
- (c) Waiving Shop Inspection. The Engineer may waive shop inspection and make complete inspection of all fabricated material when the same is delivered at the site of the work.

**505.06 Shop Painting.** Metal structures shall be cleaned and shop painted according to Articles 506.03 and 506.04.

**505.07 Marking and Shipping.** Each member shall be painted or marked with an erection mark for identification, and an erection diagram shall be furnished with erection marks thereon. Bolts of one length and diameter, and loose nuts and washers of each size, shall be packed separately. Pins, small parts and small packages of bolts, washers and nuts shall be shipped in boxes, crates, kegs or barrels, but the gross weight of any package shall not exceed 135 kg (300 lbs.). A list and description of the contained material shall be plainly marked on the outside of each package. Anchor bolts, washers and other anchorage or grillage materials shall be shipped in time to suit the requirements of the masonry construction. The loading, transportation, unloading, and storing of structural material shall be conducted so that the metal will be kept clean and free from danger of being excessively stressed, deformed or otherwise damaged.

In handling long steel members, saddles shall be placed at approximately the quarter points. In storing and shipping such members, blocking and shoring shall be placed at such intervals as will prevent sag and distortion. I-beams and built-up plate girders shall be handled, stored and shipped after painting is complete in a vertical upright and final erection position unless otherwise approved by the Engineer.

Steel lifting lugs for handling long steel members will be permitted provided their installation and removal are not detrimental to the structure and the following requirements are met:

- (a) One Contract for Fabrication and Erection. When fabrication and erection are accomplished under one contract and lifting lugs are used, the lugs shall be placed during fabrication. When no longer required, the lugs shall be removed.
  - The location, attachment and removal method for the lugs shall be detailed on the shop drawings approved by the Engineer. This work will not be paid for separately but shall be considered as included in the contract unit price bid for furnishing and erecting structural steel, and no additional compensation will be allowed.
- (b) Separate Contracts for Fabrication and Erection. When fabrication and erection are accomplished under separate contracts and lifting lugs are desired by the erector but are not shown on the plans, the erection contractor shall be responsible for submittal of shop drawings to the Engineer for approval and for having the lugs furnished and installed. When lifting lugs are detailed on the contract plans, the fabrication contractor shall

be responsible for furnishing and installing the lugs. When no longer required, the lugs shall be removed. The location, attachment and removal method for the lugs shall be detailed on the shop drawings and approved by the Engineer.

This work will not be paid for separately and no additional compensation will be allowed. When the lugs are shown on the fabrication contract plans, the cost of furnishing and installing the lugs shall be considered as included in the contract unit price bid for furnishing structural steel, and the cost of removal of the lugs and repair of the paint or base metal, if required, shall be considered as included in the contract unit price bid for erecting structural steel. When lugs are not shown on the fabrication contract plans, the entire cost involved in furnishing, installing and removing the lugs shall be considered as included in the contract unit price bid for erecting structural steel.

**505.08 Erection.** The Contractor shall erect the metal work, remove the temporary construction and do all work required to complete the structure as covered by the contract. The following requirements shall govern:

- (a) Masonry. If the substructure and superstructure are built under separate contracts, the Department will provide the masonry, constructed within allowable tolerances for lines and elevations, and properly finished, and will establish the lines and elevations required for setting the steel.
- (b) Plant. The Contractor shall provide the falsework and all tools, machinery and appliances, including pilot and driving nuts, drift pins and fitting-up bolts, necessary for the expeditious handling of the work. These items will be considered as equipment and shall remain the property of the Contractor.
- (c) Handling and Storing Materials. The loading, transporting, unloading, storing and handling of structural steel shall be according to the procedures outlined in Article 505.07 and shall be conducted so that the metal will be kept clean and free from injury. Lifting lugs for handling long steel members are permitted according to Article 505.07 and at no additional cost to the Department. When unloaded, the material shall be placed on skids above the ground. Long members, such as columns and chords, shall be supported on skids placed near enough together to prevent injury from deflection.

If the contract covering the erection of the steel does not include the fabrication, the erection Contractor shall check the material received and report promptly, in writing to the Engineer, any shortage or injury discovered. The erection Contractor shall be responsible for the loss of any material furnished by the Department or another Contractor while it is in his/her care, or for any damage to such material resulting from the erection Contractor's work.

(d) Falsework. The falsework shall be properly designed, substantially constructed and maintained for the required loads. The Contractor, if required, shall prepare and submit to the Engineer plans for falsework. Submission of the Contractor's plans will not be considered as relieving the Contractor of any responsibility.

- (e) Methods and Equipment. Before starting work, the Contractor shall provide an erection plan to the Engineer detailing the method of erection proposed to be followed and the amount and type of equipment proposed to be used. This plan shall be subject to the approval of the Engineer. The approval of the Engineer shall not be considered as relieving the Contractor of the responsibility for the safety of the Contractor's method or equipment or from carrying out the work in full.
- (f) Bearings and Anchorage. The following requirements shall apply to fixed and expansion metal bearings for metal or concrete structures placed upon masonry bearing areas.

Masonry bearing plates or castings shall not be placed upon bridge seat or other masonry bearing areas that are improperly finished, deformed or irregular. Masonry bearings shall be set level, in exact position, upon the masonry.

Lead plates shall be placed directly upon the masonry, beneath the bearing plates or castings. The concrete under each bearing shall be finished smooth and level at the proper elevation before the bearings are placed. The Contractor shall drill the holes and set the anchor bolts, except where bolts are built into the masonry. The bolts shall be set, and the holes completely filled around the bolts with an approved nonshrink grout. Preferably, the hole shall be half filled with grout and the anchor bolt tapped into place prior to final filling of the hole. Anchor bolt holes in the masonry shall be kept dry to prevent the formation of ice in them and shall be blown clean prior to setting the anchor bolts.

The location of anchor bolts in relation to slotted holes provided for expansion shall correspond with the temperature at the time of erection. The nuts on anchor bolts through moving parts at expansion bearings shall be adjusted to provide ample clearance for free movement of the span and a lock nut shall be provided where practical to keep the first nut at the proper clearance.



Anchor bolts through bearing plates under rockers or rollers shall be set, or shall be cut off after being set, so that the upper end of any anchor bolt will not project more than 15 mm (1/2 inch) above the top of the nut. Anchor bolt nuts shall be snug-tightened. Snug tightening may be attained by a few impacts of an impact wrench or the full force of a worker using an ordinary spud wrench. Rockers and rollers shall be placed accurately at right angles to the beams or girders. Top bearing plates for concrete structures shall be placed in the proper position on the rollers, rockers or bottom plates, and carefully leveled before the concrete is placed above them. Rockers, rollers and top bearing plates for concrete superstructure shall be held securely and accurately in the proper position during the construction of the superstructure, and all wedges, props or blocking used to hold them in such position shall be removed as soon as practicable after the concrete is placed.

The position of rockers or rollers and bearing plates for metal or concrete

superstructures shall be adjusted at the time they are placed so that if any anticipated forward movement of the bridge seat takes place after they have been set, the line of bearing will be centered on the bearing plates. When the plans show rockers or rollers off center of bearing plates, in anticipation of such movement of the substructure, the amount of the allowance for such movement may be adjusted by the Engineer at the time of erection to conform to conditions existing at that time. When the rockers or rollers provide for the expansion and contraction of a length of superstructure greater than 30 m (100 ft.), the temperature at the time of erection shall also be taken into account so that the line of bearing will be at the desired location on the plates and substructure at a temperature of 10 °C (50 °F.).

- (g) Straightening Bent Material. The straightening of plates, angles, other shapes and built-up members, when permitted by the Engineer, shall be done by methods that will not produce fracture or other injury. Distorted members shall be straightened by mechanical means or, if approved by the Engineer, by the careful planned and supervised application of a limited amount of localized heat, except that heat straightening of AASHTO M 270 Grades 100 or 100W steel members shall be done only under rigidly controlled procedures, each application subject to the approval of the Engineer. In all steels, other than AASHTO M 270 Grades 100 or 100W, the temperature of the heated area shall not exceed 650 °C (1200 °F.) (a dull red) as controlled by temperature indicating crayons, liquids or bimetal thermometers. Parts to be heat straightened shall be substantially free of stress and from external forces, except stresses resulting from mechanical means used in conjunction with the application of heat. Following the straightening of a bend or buckle, the surface of the metal shall be carefully inspected for evidence of fracture.
- (h) Assembling Steel. The parts shall be accurately assembled as shown on the plans. Match marks shall be followed and top of beam/weld elevations shown on contract plans shall be verified while the steel is still crane supported, before steel dead load deflection occurs. The material shall be carefully handled so no parts will be bent, broken or otherwise damaged. Hammering which will injure or distort the members will not be permitted. Bearing surfaces and surfaces to be in permanent contact shall be cleaned before the members are assembled.

Unless erected by the cantilever method, truss spans shall be erected on blocking placed so as to give the trusses proper camber. The blocking shall be left in place until the tension chord splices are fully secured with high-strength steel bolts and all other truss connections pinned and bolted. High-strength steel bolts in splices of butt joints of compression members and bolts in railings shall not be tightened until the span has been swung.

Splices in continuous beams or girders to be bolted shall not be torqued until the entire continuous length is in place on the substructure. Splices and field connections shall have 1/2 of the holes filled with finger-tight bolts and cylindrical erection pins (half bolts and half pins). Bolt tightening shall not commence until all erection pins have been removed and replaced with finger-tight bolts. Bolt tightening shall be according to Article 505.04(f). Fitting-up bolts shall be of the same nominal diameter as the specified bolts,

and cylindrical erection pins shall be 1 mm (1/32 inch) larger.

- (i) Field Bolting. High-strength steel bolts shall be assembled according to Article 505.04(f). Drifting shall be limited to draw the parts into position and not sufficient to enlarge the holes or distort the metal.
- (j) Bolted Connections. In bolted connections, where unfinished bolts or turned bolts are used, the bolts shall be brought to snug tight and loosening shall be prevented by either burring the threads at the face of the nut with a pointed tool or other mechanical means, lockwashers, self locking nuts, etc.
- (k) Pin Connections. Pilot and driving nuts shall be used in driving pins. Pins shall be driven so that the members will take full bearing on them. Pin nuts shall be tightened sufficiently to limit total lateral separation of material to less than 3 mm (1/8 inch), but not enough to clamp material and restrict rotation. Pins shall be double nutted with jam nuts or other provisions to prevent loosening of single nuts under normal service conditions, subject to approval of the Engineer.
- (I) Misfits. The correction of minor misfits involving minor field corrections will be considered a legitimate part of the erection. Minor field corrections includes grinding corners, burrs, or other small areas, removing less than 3 mm (1/8 inch) of material or reaming of less than 5 percent of holes. Plates shall either be held tightly together during reaming or disassembled for cleaning. Any error in the shop fabrication or permanent deformation resulting from handling and transportation, which prevents the proper assembling and fitting up of parts by the use of drift pins, or by minor field corrections shall be reported immediately to the Engineer for approval of the method of correction proposed. The correction shall be made in the Engineer's presence. If the contract provides for complete fabrication and erection, the Contractor shall be responsible for all misfits, errors and injuries and shall make the necessary corrections and replacements. If the contract does not include the fabrication of the steel, the Contractor performing the fabrication shall be responsible for all errors in fabrication. The Engineer will be the judge as to what misfits are considered to be of a minor nature, the correction of which is considered part of the erection work; and which are to be considered errors in fabrication, to be remedied at the expense of the fabricator. Damage occuring during transportation shall be the responsibility of the Contractor.
- (m) Stud Shear Connectors. Stud shear connectors shall be furnished as a single unit and of a design suitable for end-welding to steel with automatically timed stud welding equipment. Stud shear connectors that are to be welded to the top flanges of beams or girders shall be placed after the steel has been erected and suitable scaffolding or the deck forming has been provided so the hazard from stud projections is at a minimum. Studs that are to be welded to expansion guards, bearing plates or other secondary members may be placed in the shop.

If flux-retaining caps are used, the steel for the caps shall be of a low carbon grade suitable for welding and shall comply with ASTM A 109M (A 109). Finished studs shall be of uniform quality and condition, free from injurious laps, fins, seams, cracks, twists, bends or other injurious defects.

Finish shall be as produced by cold drawing, cold rolling or machining. The manufacturer shall certify that the studs as delivered are according to the material requirements of this Section. Certified copies of in-plant quality control test reports shall be furnished to the Engineer upon request. An arc shield (ferrule) of heat-resistant ceramic or other suitable material shall be furnished with each stud. The material shall not be detrimental to the welds or cause excessive slag and shall have sufficient strength so as not to crumble or break due to thermal or structural shock before the weld is completed. Flux for welding shall be furnished with each stud, either attached to the end of the stud or combined with the arc shield for automatic application in the welding operation.

(1) Power Source. Stud shear connectors shall be end welded with automatically timed stud welding equipment connected to a suitable power source. If 2 or more stud welding guns are to be operated from the same power source, they shall be interlocked so that only one gun can operate at a time and so that the power source has fully recovered from making one weld before another weld is started.

Studs may be welded using two or more welding generators in parallel or by use of a battery operated source to supply the necessary amperage. Good results can be achieved using either method for welding of 19 mm (3/4 inch) round studs; however, 22 mm (7/8 inch) round studs require much more power and it may be difficult to obtain good consistency in the welds using these methods.

(2) Preparation and Welding. At the time of welding, the studs shall be free from any rust, rust pits, scale, oil or other deleterious matter which would adversely affect the welding operation. The surface to receive the stud shall be reasonably free from mill scale and light rust. Paint and oil is an insulation and a contaminant and shall be removed. A light grinding of the spot under the stud is generally all that is necessary except in instances of rust or heavy mill scale.

Welding shall not be done when the base metal temperature is below -17 °C (0 °F.), or when the surface is wet. If it becomes necessary to weld the studs when the temperature of the base metal is below -17 °C (0 °F.), preheating will be required according to BWC Specifications. Preheating must be at least 10 °C (50 °F.) and the temperature of the preheated base metal shall be maintained above 0 °C (32 °F.) during the welding operation.

While in operation, the welding gun shall be held in position without movement until the weld has solidified.

Longitudinal and lateral spacings of studs with respect to each other and to edges of beam or girder flanges shall not vary more than 15 mm (1/2 inch) from the dimensions shown on the plans except that a variation of 25 mm (1 inch) will be permitted where required to avoid obstruction with other attachments on the beam. The minimum distance from the edge of a stud shank to the edge of a beam or plate shall be 25 mm (1 inch), but preferably not less than 40 mm (1 1/2 inches).

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(3) Inspection and Field Bend Tests. The first 2 studs welded on each beam or girder, after being allowed to cool, shall be bent 45 degrees by striking the stud with a hammer. If failure occurs in the weld of either stud, the procedure shall be corrected and 2 successive studs shall be successfully welded and tested before any more studs are welded to the beam or girder. This bend check should also be made at the start of each day of the work, when the welding has been interrupted for an hour or more, when changing grounds, when changing weld settings or when changing cable loop due to arc blow. In any case, no more than 500 studs shall be welded to a beam or girder without the welds being field bend tested according to the foregoing procedure. These bend tests shall be made by the operator and left in the bent position for inspection by the Engineer. All such studs that show no sign of failure as determined by the Engineer shall be left in the bent position.

Studs on which a full 360 degrees weld has not been obtained may, at the option of the Contractor, be repaired by adding a 8 mm (5/16 inch) fillet weld in place of the lack of weld, using the shielded metal-arc process with low hydrogen welding electrodes. The repair weld shall extend at least 10 mm (3/8 inch) beyond each end of the discontinuity being repaired. The Engineer will bend test questionable studs as follows: Using a heavy hammer the Engineer will strike the stud to bend in the direction opposite to the weld deficiency until the shank is bent 15 degrees from the vertical (about 25 mm (1 inch) deflection). Then reversing direction, the stud will be driven back into the vertical position. If there is no visual distress evident in the weld, it will be considered satisfactory.

In addition to the bend tests accomplished by the operator to the satisfaction of the Engineer and the bend tests made by the Engineer, the Engineer will check approximately one percent of the studs at random by striking the stud and bending it to an angle of 45 degrees with the vertical. The purpose of this random bend test is to establish the overall quality of the welding. The studs shall be left in the bent position. If due to low temperatures, preheating of the base metal has been utilized in preparation for welding of studs to the beams or girders, the operator shall hammer bend to 45 degrees from the vertical two studs in each 100 welded in addition to the first two studs welded on each beam or girder. The studs shall be left in the bent position for examination by the Engineer.

If it becomes necessary to remove a stud with a defective weld, the vacated area of the beam or girder flange shall be ground smooth and flush, or in case of a pullout of metal, the pocket shall be filled with weld metal using the shielded metal-arc process with low-hydrogen electrodes and then ground flush. The new stud shall be placed in the same dimensional location as the defective stud it replaces.

If the Engineer notes a reduction of the height of the studs as they are welded, the work shall be stopped immediately and not resumed until the cause has been corrected.

In general, if during the progress of the work, the inspection and testing indicate, in the judgment of the Engineer that the shear connectors being obtained are not satisfactory, the Contractor will be required at his/her own expense to make such changes in welding procedure or welding equipment as is deemed necessary to secure satisfactory results.

- (n) Field Welding and Cutting. Field welding shall conform to Article 505.04(q) and all field flame cutting shall conform to Article 505.04(k). No field welding or flame cutting shall be done on beams, girders or main members of trusses without the written permission of the Engineer. The use of a burning or cutting torch will be permitted only when specifically authorized by the Engineer, and only under the Engineer's personal supervision or inspection. No burning or cutting torch shall be permitted on the structure except when in use according to the above requirements.
- (o) Removal of Falsework. Equipment for pulling falsework or other piles shall not be operated upon or attached to any portion of the new structure.

**505.09 Work Under Separate Contracts.** When the fabrication, erection and painting of structural steel, construction of concrete decks, and other collateral work on a structure are accomplished under separate contracts, the following shall apply:

- (a) Storing and Protection of Structural Steel. When the fabrication and erection of structural steel is accomplished under separate contracts, the Fabrication Contractor shall be responsible for storing and protecting all fabricated structural steel up to 45 calendar days after completion dates, delivery dates or number of working days specified in the fabrication contract. All storage costs incurred by the Fabrication Contractor during this 45 day period shall be borne by the Fabrication Contractor.
- (b) Shipping of Structural Steel to Jobsite. The Erection Contractor shall provide the Fabrication Contractor and the Engineer with a schedule for shipping the structural steel to the jobsite within 30 calendar days after the execution of the erection contract. This schedule shall meet the approval of the Engineer. The Erection Contractor will be responsible for receiving, unloading, storing and protecting the structural steel in accordance with this schedule. If the Erection Contractor elects to change this schedule, the Erection Contractor shall be responsible for coordinating the change with the Fabrication Contractor and for all costs and time delays associated with such changes.

Delivery of the structural steel to the jobsite shall be the responsibility of the Fabrication Contractor. The mode of delivery shall be the option of the Fabrication Contractor unless specified otherwise by the Engineer. Delivery shall be limited to the hours between 8:00 a.m. and 5:00 p.m. on weekdays only, excluding any observed holidays, unless otherwise approved by the Engineer. The Erection Contractor shall be responsible for coordination of movement of the structural steel within the contract limits and shall be responsible for all demurrage charges. At the erection Contractor's option and expense, steel may be requested at times other than the stated time.

(c) Installation of Minor Items. Minor items of fabricated steel that cannot be completely installed until either final adjustments are made or the completion of subsequent contracts, shall be delivered and partially erected or stored as directed by the Engineer. These items shall be installed or adjusted, as required, by the Contractor performing the subsequent work.

**505.10 Field Painting.** Metal structures shall be cleaned and field painted according to Articles 506.03 and 506.05.

**505.11 Structural Steel Design.** The general features of design and the proportioning of parts shall conform to the latest edition of the AASHTO Standard Specifications for Highway Bridges, except as otherwise shown on the plans or modified by the Department.

The general features and details of design and the proportioning of parts for structures which will carry railroad traffic shall conform to the AREA SPECIFICATIONS, except as otherwise shown on the plans or modified by the Department.

**505.12 Method of Measurement.** All structural steel shown on the plans will be included for payment. All other structural metals, unless they are listed as separate pay items or incidental to other items, will be included as structural steel.

The Contractor performing the erection shall furnish the erection bolts and pins, and also pilot and driving nuts when required. The Contractor performing the fabrication shall furnish all fasteners, washers, shipping bolts and fitting-up diaphragms when required.

When minor items of structural steel are specified for payment by weight, the weight used will be the measured mass (weight) of the fabricated structural steel furnished. No measurement will be made or allowed for the mass (weight) of field weld material. The structural steel will be measured in kilograms (pounds) using the approved shipping mass (weight) or by measuring on approved platform scales. When the plan quantities of minor items of structural steel, such as expansion dams on concrete bridges or miscellaneous steel for the repair of existing structures, is approximately 4500 kg (10,000 lbs.) or less, the method of measurement for payment will be in accordance with Article 202.07(a) unless a weigh ticket is provided.

**505.13 Basis of Payment.** Structural steel and other material complying with the requirements of this item, furnished and erected complete in place, according to the specifications, and accepted, will be paid for at the lump sum price for FURNISHING AND ERECTING STRUCTURAL STEEL, which price shall be payment in full for all materials and for fabrication, shop work, transportation, erection and shop painting. Field painting shall also be included unless otherwise provided in the contract.

Fabricated structural steel and other material complying with the requirements of this item, furnished and accepted, will be paid for at the lump sum price for FURNISHING STRUCTURAL STEEL, which price shall be payment in full for all materials, and for fabrication, shop work, application of the shop coat of paint and delivery F.O.B. the unloading point specified.

Storage and care of the fabricated steel by the fabrication contractor beyond the specified storage period, will be paid for at the contract unit price per calendar day for STORAGE OF STRUCTURAL STEEL if a pay item is provided for in the contract, or will be paid for according to Article 109.04 if a pay item is not provided in the

contract.

Structural steel and other material fabricated under this item erected according to the requirements of the specifications, and accepted, will be paid for at the lump sum price for ERECTING STRUCTURAL STEEL, which price will be payment in full for unloading, transporting from the unloading point to the bridge site, erection of the fabricated structural steel, and the application of paint for spot painting bolt heads, field welds and abrasions to the shop coat of paint. This price will also be payment in full for furnishing and for the application of the field coats of paint, unless otherwise provided in the contract.

If alterations or deductions to the work specified in the aforementioned lump sum items are ordered by the Engineer, the Contractor shall accept payment for any increase or decrease in the amount of structural steel and other materials under the terms specified in Article 104.02(a). The unit price used for the adjusted work will be determined by dividing the lump sum price bid for the item by the Engineer's calculated weight as shown on the contract plans. No adjustment in this plan weight will be allowed in calculation of the unit price for the adjusted work. Weight in kilograms (pounds) for the increased or decreased amounts of structural steel and other structural metals will be computed on the basis of the nominal weights shown in the current edition of the AISC Manual. When the increase or decrease in the quantity of structural steel or other structural metals ordered by the Engineer amounts to a change exceeding 0.5 percent of the Engineer's calculated weight as shown on the contract plans or 1360 kg (3000 lbs.), whichever is larger, the unit price used for the increased or decreased amount of structural steel shall be agreed upon by the Contractor and the Engineer.

When specified, minor items of structural steel complying with the requirements of this item, furnished and erected complete in place, according to the specifications, and accepted, will be paid for at the contract unit price per kilogram (pound) for FURNISHING AND ERECTING STRUCTURAL STEEL.

Stud shear connectors that are to be field welded to the top flanges of beams or girders, furnished and installed in accordance with the specifications, and accepted, will be paid for at the contract unit price each for STUD SHEAR CONNECTORS.

# SECTION 506. CLEANING AND PAINTING METAL STRUCTURES

**506.01 Description.** This work shall consist of the cleaning and preparation of steel surfaces; the furnishing, application and protection of the paint coatings; and incidental work on new and existing steel structures.

**506.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 - Materials:

	Item	Article/Section
(a)	Paint Materials and Mixed Paints	1008.01 - 1008.23
(b)	High Strength Steel Bolts, Nuts and	Washers 1006.08

## Cleaning and Painting Metal Structures

#### CONSTRUCTION REQUIREMENTS

**506.03 Cleaning New Structures.** Surfaces of all steel to be shop painted, field spliced, and surfaces to receive stud shear connectors, shall be blast cleaned in the shop, removing rust, mill scale, dirt, oil or grease and other foreign substances. Blast cleaning shall be accomplished according to the requirements of the Steel Structures Painting Council Surface Preparation Specification SP 10 for Near-White Blast Cleaning. Special attention shall be given to the cleaning of corners and reentrant angles.

Before painting, all blast products shall be removed from the surfaces, and the cleaning shall be approved by the Engineer. The blast-cleaned surfaces shall be given a prime coat of paint within 24 hours after cleaning, unless otherwise authorized by the Engineer. The surface must be primed before rust forms. Where touch-up of prime coat is required, cleaning of small areas may be accomplished with power tools. Larger areas shall be blast cleaned. All cleaned surfaces shall have an anchor profile of 25  $\mu m$  to 65  $\mu m$  (1 to 2.5 mils).

Surfaces of new work to be field painted for the first time shall be cleaned with wire brush, power tools or blast cleaned, as specified for touch-up of prime coat, to remove all rust that has developed or become apparent after the shop painting. Before the application of the finish coat, the prime coat shall be cleaned of all dirt, oil, oxidation products and other foreign substances by high pressure water. The surfaces shall be completely dry at the time of the application of the finish coat.

- **506.04** Shop Painting New Structures. Except as otherwise specified, all steel work shall be given one coat of paint at the fabricating plant after the fabrication has been completed and approved. The fabricated steel shall not be loaded for shipment until the shop paint is dry and has been inspected and approved by the Engineer. Structural steel shall not be loaded for shipment sooner than 24 hours after application of paint. No painting shall be done after the material has been loaded for shipment. The shop painting of steel structures shall conform to the following requirements:
  - (a) Paint. The paint for the shop coat shall be the inorganic zinc-rich primer according to Article 1008.22. The paint shall be stored at 5 °C (40 °F.) or higher.
  - (b) Mixing of Paint. The paint shall be thoroughly mixed with a power mixer before being applied and the pigments shall be kept in suspension. Inorganic zinc-rich primer, after initial mixing, shall be strained through a metal screen not coarser than 600 μm (30 mesh) or finer than 250 μm (60 mesh), before application. When inorganic zinc-rich primer is being applied, the material must be kept under constant agitation with a power mixer to avoid settling.
    - Thinning will be permitted when required for proper application. The type of thinner used and the amount used shall be as recommended by the paint manufacturer.
  - (c) Weather Conditions. Paint shall not be applied when the temperature of either the metal or the air is less than 5 °C (40 °F.), or when conditions are otherwise unsatisfactory for such work. The relative humidity shall be

between 50-90 percent. The surface of the steel shall be dry when the paint is applied and the painted work shall be kept above 5 °C (40 °F.) for 10 hours minimum after paint application. When the weather is such that steel stored in the open might become colder than 5 °C (40 °F.) before the paint is dry, the steel shall be painted in the shop or other enclosed space which is heated so that the temperature will not be below 5 °C (40 °F.) for 10 hours minimum after paint application. Material painted under cover in damp or cold weather shall remain under cover for 10 hours minimum after paint application until weather conditions permit its exposure in the open. Painting shall not be done when the steel is hot enough to cause the paint to blister or produce a porous paint film.

(d) Application. Paints shall be applied by either airless or conventional spray methods, except areas inaccessible to spray application may be painted by brush or daubers, and small touch-up areas may be painted by brush. When inorganic zinc-rich primer is applied by spray, a mechanically agitated pressure pot shall be used. The pressure pot and spray gun shall be approximately the same height while spraying with conventional equipment. Application of paint shall produce a smooth, uniform coating. The paint shall be thinned for spraying to suit prevailing weather conditions so that a wet spray is provided at all times and the deposition of particles which are dry when they strike the surface is avoided. In this regard, care shall be used to insure that the spray nozzle is held close enough to the surface to avoid excessive loss of volatiles.

The coating shall be applied so that an average dry-film thickness of at least 75  $\,\mu m$  (3.0 mils) is obtained. The minimum dry-film thickness of an inorganic zinc-rich prime coat measured at any spot shall be at least 65  $\,\mu m$  (2.5 mils), except as otherwise specified for contact surfaces of high-strength bolted connections. If a paint coating is too thin or if portions of the steel are not coated completely, such portions of the work as directed by the Engineer shall be repainted.

When the proper dry-film thickness of an inorganic zinc-rich prime coat is not obtained with one coat, all contaminants, if present, shall be removed, and an additional coat of primer applied that has been thinned according to the paint manufacturer's recommendations. The maximum dry film thickness shall be 150  $\mu m$  (6.0 mils) for a single coat and 200  $\mu m$  (8.0 mils) for multiple coats.

- (e) Removal of Unsatisfactory Paint. If the paint coat wrinkles or shows evidence of having been applied under unfavorable conditions, or if the workmanship is poor, the Engineer may order it removed and the steel cleaned and repainted. All areas where "mud cracking" occurs in a film of inorganic zinc-rich primer shall be scraped back to soundly bonded paint and recoated. Areas adjacent to the removal of unsatisfactory paint shall be feathered to provide a smooth transition between originally applied paint and paint re-applied.
- (f) Contact and Inaccessible Surfaces. Surfaces in contact to be welded or bolted in the shop need not be painted unless specified, but shall be cleaned of loose rust, scale and foreign material to meet the approval of the Engineer. Surfaces not in contact, but which will be inaccessible after

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assembly or erection, shall be painted in the shop with the shop primer. Field contact surfaces shall be painted one coat of the inorganic zinc-rich primer in the shop. The dry-film thickness for a inorganic zinc-rich prime coat on field contact surface shall be 25 to 125  $\mu$ m (1.0 to 5.0 mils).

- (g) Surfaces in Contact with Concrete. Tops of beams and girders that are to have concrete poured in contact with them shall be given one shop coat of paint, except that portions of the top surfaces of the top flanges of these beams and girders which are to receive stud shear connectors shall not be painted. Other steel surfaces, including bearings and all portions of expansion guards except anchor straps or bars, that are to be in contact with or partially embedded in concrete, shall be painted. Steel that is to be completely embedded in concrete shall not be painted except when specified.
- (h) Machine-finished Surfaces. Machine-finished surfaces of pins, pin holes, rollers or other finished surfaces that will be subjected to friction, shall be coated as soon as practicable after being approved, with lacquer or an anti-rust compound. When anti-rust compound is used, it shall be removed at the time of erection.
- (i) Bearing Surfaces. All surfaces of rockers, bolsters, shoes, base plates, rollers, and bearing plates shall be given one coat of the shop paint.
- (j) Connectors. All high-strength bolts and other connectors, including nuts and washers, that are furnished for installation in the shop or field shall be zinc-coated according to Article 1006.08.
- (k) Erection Marks. Erection marks and match marks shall be painted upon areas that have received a coat of the shop paint.

**506.05** Field Painting New Structures. The requirements of Article 506.04, paragraphs (b) to (e), inclusive, shall also apply to field painting of new structures. The Contractor shall protect pedestrian, vehicular, watercraft, or other traffic upon or underneath the structure and also all portions of the structure against damage or disfigurement by paint. When painting over waterways, the Contractor shall implement such controls as are necessary to avoid paint spills into the water or paint films from collecting on the water from spraying operations.

Field painting shall consist of spot painting and application of the additional paint coatings required. Paint may be applied by spray or with brushes as specified in Article 506.04(d). Airless equipment shall be used when spray painting is done in the field. In addition, the use of rollers will be permitted in the application of paint coatings to flat surfaces, provided satisfactory results are obtained. Only brushes or rollers shall be used when spray painting is prohibited by the Special Provisions. If the structure includes a concrete deck, field painting shall be done after the deck is poured and the forms have been removed.

When a structure has been cleaned to the satisfaction of the Engineer, it shall be spot painted. The spot painting shall consist of the application of one coat of high build aluminum epoxy mastic paint applied on the heads of field bolts, pins, field welds, and all areas where the paint has been removed or damaged. The dry film thickness of the aluminum epoxy mastic shall be 125 to 175  $\mu$ m (5.0 to 7.0 mils). Spot painting shall be done as soon as the cleaning operations will permit and as far

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as possible in advance of the first field coat of paint, but not until the cleaning is far enough ahead to eliminate danger of dirt or other material from the cleaning operations falling or blowing on the spot coat. Areas requiring spot painting, shall be cleaned as specified in Article 506.03.

The sequence of the work shall be arranged so as to provide ample time for each paint coating to dry before the next coat of paint is applied. In no case shall a coat of paint be applied until the previous coat has been inspected by the Engineer and found to be dry and hard throughout the entire film thickness.

Except as provided herein, field painting shall be done after the erection is completed. Surfaces that would be inaccessible for field painting after the erection is entirely completed shall be painted at such times as directed by the Engineer, during the erection or prior to installation.

Surfaces that are to have concrete poured in contact with them shall receive no field paint.

- (a) The number of coats, colors, and types shall be as specified in the contract.
- (b) Machine-finished Surfaces. Exposed surfaces of pins, rollers or other machine-finished surfaces that have been coated with anti-rust compound or lacquer prior to shipment, shall be cleaned with wire brush or power tool prior to painting. The exposed surfaces of rollers or other machine-finished surfaces shall be painted with one coat of the paint used for spot painting, and painted with the paint specified for field painting the structure. The exposed ends, threaded parts and nuts of pins shall be painted with one coat of approved high-build, aluminum epoxy mastic, and painted with the paint specified for field painting the structure. The dry film thickness of the aluminum epoxy coating shall be in the 125 to 175 μm (5.0 to 7.0 mils) range and it shall not be applied when the surface temperature is below 10 °C (50 °F.), or when the temperature is expected to drop below 10 °C (50 °F.) before coating has cured.
- (c) Work Under Separate Contracts. All field cleaning and painting of new work shall be included as part of the work to be performed under the contract that includes the erection of the steel. When complete field painting is not included in the contract that includes the erection, the spot painting of newly erected work and the field painting of surfaces inaccessible after erection shall be included as part of the work to be performed under the contract that includes the erection. Field painting under any contract that does not include the erection shall include such cleaning and spot painting as may be required at the time the work is performed, and the additional paint coatings required.
- (d) Inspection. The Contractor is responsible to provide the Engineer adequate access for inspection during all stages of work performed.

The Contractor shall stencil in contrasting color paint the date of painting and the paint type code from the Structure Information and Procedure Manual. The letters shall be capitals, not less than 50 mm (2 inches) and not more than 75 mm (3 inches) in height. The stencil shall contain the word "Painted" and shall show the month and year in which the painting was completed followed by the proper paint type code. This shall be stenciled on the top plate of a truss end post near the top of the railing,

## Cleaning and Painting Metal Structures

or on the outside face of an outside stringer near both ends of the bridge facing traffic, or at some equally visible surface designated by the Engineer.

- **506.06 Method of Measurement.** Shop cleaning and painting new structures will not be measured for payment. Field cleaning and painting will not be measured for payment except when performed under a contract that contains a separate pay item for this work.
- **506.07 Basis of Payment.** Cleaning and painting in connection with the fabrication and erection of steel structures will not be paid for separately but shall be considered as included in the contract unit price or prices for furnishing, fabricating and erecting, or installing the material.

The field cleaning and painting of newly erected structural steel under a contract separate from the fabrication and erection will be paid for at the lump sum price for PAINTING STRUCTURAL STEEL, and the field cleaning and painting of steel railings which are fabricated and erected at a contract unit price per meter (foot) will be paid for at the contract unit price per meter (foot) for PAINTING STEEL RAILING when performed under a contract separate from the erection.

#### SECTION 507. TIMBER STRUCTURES

- **507.01 Description.** This work shall consist of timber construction required for bridges and appurtenances, where the timber is incorporated in the completed structure. All lumber and timber for erection purposes, such as falsework, forms, sheeting, bracing, etc., shall be furnished by the Contractor at his/her own expense and is not subject to the requirements of this Section.
- **507.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 Materials:

	Item	Article	/Section
(a)	Timber for Bridges		1007.04
(b)	Timber Piling		1007.08
(c)	Preservative Treatment		1007.12
(d)	Hardware		1006.17
 (e)	Structural Steel		1006.04
(f)	Structural Steel	1009.01 -	1009.05
(g)	Fine Aggregate		1003.03
(h)	Paint Materials and Mixed Paints	1008.01 -	1008.23

Structural steel and other metals requiring fabrication shall be fabricated according to Section 505.

#### CONSTRUCTION REQUIREMENTS

**507.03 Storage of Materials.** Untreated lumber at the site of the work shall be open-stacked on supports at least 300 mm (12 inches) above the ground and shall be so stacked and stripped as to permit free circulation of air between the tiers and courses. When required by the Engineer, it shall be protected from the weather by

suitable covering. Treated timber shall be close-stacked according to Article 1007.12.

**507.04 Workmanship.** All timber shall be accurately cut and framed to a close fit in such manner that the joints will have even bearing over the entire contact surfaces. Unless otherwise specified, nails and spikes shall be driven just sufficiently to set the heads flush with the surface of the wood. Deep hammer marks in wood surfaces shall be considered evidence of poor workmanship.

**507.05 Treated Timber.** All cutting, framing and boring of treated timber shall be done before treatment insofar as is practicable.

- (a) Handling. Treated timber shall be handled carefully without sudden dropping, bruising, breaking of outer fibers or penetrating the surface with tools. It shall be handled with rope slings. Cant hooks, peaveys, pikes or hooks shall not be used.
- (b) Cuts, Abrasions, and Holes. All cuts, abrasions, and holes made after treatment shall be according to Article 1007.12(f). Each coat shall be allowed to dry before the next coat is applied. Any unfilled holes, after being treated with preservative oil, shall be plugged with treated plugs.
- (c) Temporary Attachments. Forms or temporary braces may be attached to treated timber with nails or spikes only when approved by the Engineer. Upon their removal, the holes shall be filled by driving galvanized nails or spikes flush with the surface, or by plugging as required for holes.
- **507.06 Countersinking.** Countersinking shall be done wherever smooth faces are required. Recesses formed in treated timber for countersinking shall be treated as required for cuts and abrasions, except as specified for plank floors.
- **507.07 Hardware.** The term Hardware shall include all metal fastenings required for timber connections or for connecting timber to concrete or steel work. The following items will be considered as Hardware: bolts, tie rods, turnbuckles, washers, nuts, drift bolts, steel dowels, nails, spikes and lag screws for timber connections; steel plates used as washers or between timber caps and the tops of piles or timbers; metal timber connectors of various designs; metal shear developers for composite timber and concrete floors; and anchor plates or clips for plank floors and sidewalks. Sheet metal pile coverings and steel traffic treads and their fastenings are not considered as Hardware.

All hardware for treated timber construction, except cast iron O. G. washers and malleable iron washers and timber connectors shall be galvanized.

- (a) Rods. Rods connecting only sawed timbers shall be threaded sufficiently at each end to provide tight connections, allowing for permissible variations in dimensions of material. All rods shall extend entirely through the nut at each end and, after being drawn tight, all ends that project more than 25 mm (1 inch) beyond the nut shall be cut off about 15 mm (1/2 inch) beyond the nut.
- (b) Bolts. The length specified shall be the length measured under the head. Bolts may be substituted for rods for timber connections where the length of threaded portion provided by the bolt is sufficient. Bolt ends projecting

- more than 25 mm (1 inch) beyond the nut shall be cut off as specified for rods. Special flat head bolts, or carriage bolts, shall be used for connections horizontally through railings and wheel guard timbers, with the head at the roadway face of the timbers. Machine bolts with square heads and nuts shall be used for other connections.
- (c) Lag Screws. Lag screws shall be installed by turning them into place. They may be driven sufficiently to start them into the holes and hold them firmly in place for turning, but shall not be driven beyond the depth that will be occupied by the shank.
- (d) Nuts and Washers. Washers shall be used under all nuts and bolt heads that would otherwise come in contact with wood, except under large diameter heads of specially designed flat head bolts. O. G. or malleable iron washers shall be used for all tie rods except where plate washers are called for by the plans, and for all rods and bolts passing through piles except bolts connecting railing plank to wing piles. Standard wrought washers shall be used at all locations except where washers of other types are required. All nuts shall be standard square nuts. They shall be tightened sufficiently to prevent the rods or bolts from becoming loose during service and, after being tightened, they shall be effectively secured against backing off by burring of the rod or bolt threads, or as otherwise specified or approved by the Engineer.
- (e) Nails and Spikes. Nails shall not extend through all material into which they pass except when approved by the Engineer. The size of nails and spikes, when not otherwise shown, shall conform to the following:

		l
	Size of Nails	
Actual	Actual	Size
Thickness of	Thickness of Piece	of
Piece Nailed	Nailed to	Nails
mm (inch)	mm (inch)	
41 (1 5/8)	41 (1 5/8)	10d
41 (1 5/8)	50 (2)	16d
41 (1 5/8)	66 (2 <sup>°</sup> 5/8) or more	20d
50 (2)	50 (2)	16d
50 (2)	66 (2 5/8) or more	20d
66 (2.5/8)	66 or 75 (2 5/8 or 3)	40d
66 (2 5/8)	92 (3 5/8) or more	60d
75 (3)	75 (3)	50d
75 (3)	92 (3 5/8) or more	60d
92 (3 5/8)	92 Špikes (3 5/8)	
100 (4)	92 or more (3 5/8)	178 mm (7") spikes

**507.08** Holes for Bolts, Dowels, Rods and Lag Screws. Holes for round drift bolts and dowels shall be bored with a bit 2 mm (1/16 inch) less in diameter than the bolt or dowel to be used. The diameter of holes for square drift bolts or dowels shall be equal to the least dimension of the bolt or dowels. Holes for bolts shall be bored with a bit of the same diameter as the bolt. Holes for rods shall be bored with a bit 2 mm (1/16 inch) greater in diameter than the rod. Holes for lag screws shall be bored

with a bit not larger than the body of the screw at the root of the thread. If required to prevent splitting, the hole for the shank shall be bored the same diameter as the shank. The depth of holes for lag screws shall be approximately 25 mm (1 inch) less than the length under the head.

- **507.09** Pile Bents and Abutments. All work involving piles shall conform to Section 512. Cut-offs shall be made accurately to ensure perfect bearing between the cap and piles, or good alignment of the tops of wing piles. No shimming between pile tops and caps will be permitted except to provide for adjustment of not more than 25 mm (1 inch) required on account of errors in cut-off. The shim for this purpose shall consist of a single square steel plate of the proper thickness, having the same width as the cap, punched 2 mm (1/16 inch) larger than the drift bolt, and shall be furnished and placed at the sole expense of the Contractor. The piles for any one bent or line shall be selected carefully as to size, to avoid undue bending or distortion of the bracing or backing timbers. Care shall be exercised in the distribution of piles of varying sizes to secure the required strength and rigidity throughout the structure.
- **507.10 Caps.** Timber caps shall be placed, with ends aligned, in a manner to secure an even and uniform bearing on the tops of the supporting posts or piles. They shall be secured by a drift bolt not less than 20 mm (3/4 inch) in diameter, extending at least 225 mm (9 inches) into each post or pile. The drift bolt shall be as near the center of the post or pile as possible without interfering with rods passing through the post or pile near the cap. Caps shall not be spliced except as provided by the plans.
- **507.11 Backing Plank.** Backing plank shall be placed so that exposed ends form a straight line. They shall be fastened to each pile and nailing strip with at least 2 nails or spikes. Splices in backing plank shall be made at the center of a pile and splices in adjoining lines or plank shall be staggered. Backing plank for wings shall be placed so that the top of the top plank will be at the proper elevation.
- **507.12 Stringers.** Timber stringers shall be placed in position so that the floor will have an even bearing on all stringers and so that any knots near edges will be in the top portions of the stringers. Outside stringers may have butt joints, centered over caps or floor beams, but interior stringers shall be lapped to take bearing over the full width of the cap or floor beams at each end. Stringers shall be toenailed to caps and intermediate stringers of adjoining spans shall be spiked together where they lap.

Cross-bridging between stringers shall be neatly and accurately framed, and securely toenailed with at least 2 nails in each end. All cross-bridging members shall have full bearing at each end against the sides of stringers. Unless otherwise specified, 50-mm (2-inch) by 100-mm (4-inch) cross-bridging shall be placed at the center of each span.

**507.13 Plank Floors.** Unless otherwise shown, the floor planks shall be laid at right angles to centerline of roadway. The planks shall be carefully graded as to thickness and laid so that no 2 adjacent planks will vary in thickness by more than 2 mm (1/16 inch). When more than one length of plank is required, joints between abutting ends shall be staggered at least 1 m (3 ft.) in any 2 adjacent lines of plank. Ends of planks at the edges of the roadway shall be cut on a straight line parallel with the centerline of the roadway.

When plank floors on steel stringers are to be fastened to nailing strips bolted to

the sides of the steel stringers, the top of each nailing strip shall be flush with the top of the beam or channel. A recess of the proper width and depth shall be provided in the top surface of the nailing strip to fit neatly around the projecting flange of the beam or channel. Nailing strips for treated plank floors shall be so recessed before treatment.

In constructing floors of untreated material, the planks shall be laid heart side down with 5 mm (1/4 inch) joints between them for seasoned material and with tight joints for unseasoned material. Treated plank floors shall be laid with tight joints except when the planks are separated by anchor clips used for fastening the planks to steel stringers.

Standard wrought washers shall be used under the heads of all lag screws and under the heads or nuts of all machine bolts used for fastening the floor plank. Where machine bolts are used for fastening the floor plank, all nuts used shall be locknuts. Heads of all lag screws and bolts in the surface of the floor shall be countersunk so that the tops will be flush with the surface of the plank. Recesses formed for countersinking shall be just large enough to admit the washers and, after the lag screw or bolt is in place, shall be filled with hot pitch.

For laminated or Strip Floors, the strips shall be placed on edge and each strip shall be nailed to the preceding strip at each end with 2 nails and approximately at 450-mm (18-inch) intervals with nails driven alternately near the top and bottom edges. The nails shall be long enough to pass through 2 strips and at least halfway through the third strip. If timber stringers or nailing strips are used, every other strip shall be toenailed to every other support. Care shall be taken to have each strip vertical and tight against the preceding one, and bearing evenly on all supports.

- **507.14 Bituminous Surface Coat.** When required, plank floors shall be given a bituminous surface coat. The floor shall be cleaned of foreign materials and the asphalt cement shall be applied at a temperature of from 135 °C to 175 °C (275 °F. to 350 °F.) and at a rate of approximately 1 L/m² (1/4 gal. per sq. yd.) of surface. The plank shall be dry at the time of this application. The entire surface shall then be covered with a thin coating of fine aggregate, sufficient in quantity to take up any free bitumen.
- **507.15 Steel Traffic Treads.** Steel traffic treads shall be not less than 5 mm (3/16 inch) thick, exclusive of the raised portions, not less than 600 mm (24 inches) wide, and the individual sections not more than 4.5 m (15 ft.) long. Treads shall have a non-skid surface with alternate projections at right angles to each other. The raised portions shall be formed in the rolling and not by punching or pressing from the under side. Treads shall be punched 11 mm (7/16 inch) for lag screws or bolts. The holes shall be placed not less than 30 mm (1 1/4 inches) nor more than 40 mm (1 1/2 inches) from the edge of the tread. The spacing of holes on both sides of the tread shall be not more than 375 mm (15 inches) and on both ends of each section not more than 150 mm (6 inches). The unit weight of the treads shall be approximately 43 kg/m² (8 3/4 lbs. per sq. ft.).

Before the treads are laid, all high spots and rough spots in the plank floor shall be removed so that the treads will be in contact with the floor for their full length and width. Treads shall be laid in a heavy mop coat of hot asphalt conforming to Article 1009.06, PAF-3. Treads shall be laid with a space of 5 mm (1/4 inch) between adjacent ends and shall be fastened by means of M10 (3/8 inch) galvanized bolts. Where bolts cannot be installed, M10 (3/8 inch) by 75 mm (3 inch) galvanized screws

shall be used.

**507.16 Wheel Guards and Railings.** Wheel guards and railings shall be accurately framed so that they will be true to line and grade. Wheel guards shall be laid in sections not less than 3.6 m (12 ft.) long with each splice located approximately over the center of a scupper block. Railing plank shall be untreated timber and shall be painted 2 coats of white paint. Surfaces in contact with rail posts or piles shall be painted one coat before the railing planks are erected.

#### 507.17 Method of Measurement.

- (a) Contract Quantities. The requirements for the use of Contract Quantities shall conform to Article 202.07(a).
- (b) Measured Quantities. The quantity of timber will be computed in cubic meters (foot board measure). Computations of quantity will be based on the nominal commercial widths and thicknesses of the material. The length will be the actual lengths of the various pieces required, measured to the nearest 25 mm (inch). The length of each piece with a beveled end will be taken as the overall length of the piece, except that when 2 or more pieces with beveled ends may be cut economically from a single commercial length, the sum of the lengths will not exceed the commercial length required. The quantity computed for payment will include all splices required by the plans but will not include any allowance for additional splices or waste.

The weight of hardware will be computed in kilograms (pounds) by the Engineer. The weight of rods and plates will be computed from the weights shown in the current edition of the American Institute of Steel Construction Manual, with no deduction for holes and no allowance for overrun. Weights computed from dimensions of material will be based upon a weight of 7850 kg/m³ (490 lbs. per cu. ft.) for steel, 7770 kg/m³ (485 lbs. per cu. ft.) for wrought iron, and 7200 kg/m³ (450 lbs. per cu. ft.) for cast iron. No additional allowance for loss or waste will be added to the computed weights, but an additional allowance of 3 1/2 percent for galvanizing will be added to weights of all galvanized material computed on the basis of ungalvanized material.

Bituminous surface coat for plank floors will be measured for payment in square meters (square yards).

Steel traffic treads will be measured for payment in square meters (square feet).

**507.18 Basis of Payment.** All work and materials involved in the construction of timber structures will be paid for at the contract unit prices for the various unit price items of the contract. Treated timber will be paid for at the contract unit price per cubic meter (foot board measure) for TREATED TIMBER. Untreated timber, including any painting required, will be paid for at the contract unit price per cubic meter (foot board measure) for UNTREATED TIMBER. All items classed as hardware will be paid for at the contract unit price per kilogram (pound) for HARDWARE. Bituminous surface coat for plank floors will be paid for at the contract unit price per square meter (square yard) for BITUMINOUS SURFACE COAT. Steel traffic treads, including bolts,

lag screws, or other fastenings, will be paid for at the contract unit price per square meter (square foot) for STEEL TRAFFIC TREADS.

### **SECTION 508. REINFORCEMENT BARS**

**508.01 Description.** This work shall consist of furnishing and placing reinforcement bars.

**508.02** Materials. Materials shall meet the requirements of Article 1006.10.

#### **CONSTRUCTION REQUIREMENTS**

**508.03** Storage and Protection. The reinforcement bars, when delivered on the job, shall be stored above the surface of the ground upon platforms, skids or other supports, and shall be protected from mechanical injury and from deterioration by exposure. When placed in the work, they shall be free from dirt, detrimental scale, paint, oil or other foreign substances. A light coating of rust will not be considered objectionable. For epoxy-coated reinforcement bars, all systems for handling shall have padded contact areas. The bars or bundles shall not be dropped or dragged. Coated bars shall be stored on wooden or padded steel cribbing.

**508.04** Cutting and Bending. Reinforcement bars shall be cut and bent at the mill or shop to the shapes shown on the plans before shipment to the work. Bending in the field will not be permitted except to correct errors, damage by handling and shipping, and minor omissions in shop bending.

Epoxy-coated reinforcement bars on skewed bridges and in other locations that are specified to be cut in the field shall be either sawed or sheared but shall not be flame cut. Patching of the bar cuts shall be according to ASTM D 3963 specifications.

**508.05 Placing and Securing.** All reinforcement bars shall be placed and tied securely at the locations and in the configuration shown on the plans prior to the placement of concrete. Reinforcement bars shall not be placed by sticking or floating into place during or immediately after placement of the concrete.

Bars shall be tied at all intersections except where the center to center dimension is less than 300 mm (1 ft.) in each direction, in which case alternate intersections shall be tied. The number of ties as specified shall be doubled for lap splices at the stage construction line of concrete bridge floors when traffic is allowed on the first completed stage during the pouring of the second stage.

Prior to the placement of any concrete, all mortar or other foreign material shall be removed from the reinforcement. Placement of the concrete shall not commence until the Engineer has inspected and approved the reinforcement placement. The Contractor shall correct any misalignment of the reinforcement bars occurring during the placement of the concrete.

The clearances from the face of the form shall be maintained by the use of chairs or other supports approved by the Engineer. Clearance from the bottom of footing shall be maintained by concrete blocks, cement bricks, suspended in place, or other supports system approved by the Engineer. Pebbles, stones, building bricks, and wood blocks shall not be used for bar supports. Bars in the bottom of beams and girders shall be supported by chairs placed on the forms. In beams and girders

having two or more layers of bars, the chairs for the upper layer shall rest on the immediate lower layer, top bars in beams and girders shall be supported from the adjacent slab or from the stirrups.

Supports shall be metal or plastic. Metal bar supports shall be made of cold-drawn wire, or other approved material and shall be either epoxy coated, galvanized or plastic tipped. When the rebars are epoxy coated, the metal supports shall be epoxy coated. The supports may be recycled plastic. Supports shall be provided in sufficient number and spaced to provide the required clearances. All supports shall meet the approval of the Engineer.

Bars in the bottom of concrete bridge floors shall be supported from the forms on continuous type bar supports placed transversely to the bottom bars at a maximum spacing of 1 m (3 ft.-3 inches). Bars in the top of concrete bridge floors shall be supported on continuous high chairs placed transverse to the bottom bars of the top mat at a maximum spacing of 900 mm (3 ft.). Individual high chairs may be used to support the bars in the top of concrete bridge floors in lieu of continuous high chairs. If individual high chairs are used, they shall be spaced at a maximum of 600 mm (2 ft.) by 900 mm (3 ft.) centers, or equivalent. The requirements, as herein specified, for supporting bars in concrete bridge floors are minimum requirements only and the Contractor is in no way relieved of the responsibility of providing additional supports as may be required to support the bars firmly in their correct position. When working loads on the bars prior to and during concrete placement includes chutes, pipes or tubes for pumping concrete, or other unusual material or equipment, special consideration shall be given to the need for supplementary bar supports.

In addition to the requirements for tying bars at intersections, as herein specified, the bars in the tops of slabs shall be securely held in place by 3.8 mm (No. 9) wire ties, or other devices fastened to the structural steel, falsework or other structural component at a maximum of 7.6 m (25 ft.) longitudinal and 4.5 m (15 ft.) transverse spaces. Welding to the structural steel will not be permitted.

Epoxy-coated reinforcement bars shall be tied with plastic or epoxy coated wires or acceptable molded plastic clips. After the bars are in place and immediately before placement of the concrete, the coated bars will be inspected for damage to the coating. Damage caused during shipment of epoxy bars or by installation procedures or both need not be repaired in cases where the damaged area is 5 x 5 mm (1/4 x 1/4 inch) or smaller, and the sum of all damaged areas in each 300 mm (1 ft.) length of bar does not exceed 2 percent of the bar surface area. All damaged areas larger than 160 mm² (1/4 sq. inch) shall be repaired and all bars with total damage greater than 2 percent of bar surface area in any 300 mm (1 ft.) length of bar shall be rejected and removed. The total bar surface area covered by patching material shall not exceed 5 percent. Epoxy-coated bars at bonded deck construction joints shall be protected from coating damage during preparation of the joint surfacing for bonding. If sandblasting is used in preparation of the joint area, as allowed in Article 503.09(a), the Contractor shall be required to wrap or otherwise protect the bar coating during the blasting operation.

Prior to the placement of concrete for bridge decks, the clearance for the top mat of reinforcement bars shall be checked. A template shall be attached to the finishing machine or vibrating screed and a dry run shall be made over the entire area of the deck. The template shall be set to 6 mm (1/4 inch) less than the specified clearance to allow for tie wires. Any reinforcement exceeding the allowable tolerance shall be corrected before the start of concrete placement.

**508.06 Splicing.** Reinforcement bars shall be furnished in the full lengths indicated upon the plans. No splicing of bars, except where indicated on the plans, will be permitted without the written approval of the Engineer. All reinforcement bars specified along a continuous line of bars shall be lapped the specified length and shall be contact spliced and wired together. All lapping reinforcement bars, not specified along a continuous line and contact spliced, shall be placed a clear distance apart of at least 65 mm (2 1/2 inches) or contact spliced, whichever requires the least adjustment in the bar spacing specified.

Splicing of reinforcement bars by welding will not be allowed.

#### 508.07 Method of Measurement.

- (a) Contract Quantities. The requirements for the use of Contract Quantities shall conform to Article 202.07(a).
- (b) Measured Quantities. Reinforcement bars and epoxy coated reinforcement bars incorporated in special reinforced pavement designs and in structures will be measured in kilograms (pounds) as computed for the sizes and lengths of bars shown on the plans or authorized by the Engineer. In computing the quantity to be paid for, the quantity of the bars of the cross section shown on the plans, or authorized, will be used. These weights are given in the following table:

Size of Bars Metric	Weight in Kilograms per Meter
No. 10	0.785
No. 15	1.570
No. 20	2.355
No. 25	3.925
No. 30	5.495
No. 35	7.850
No. 45	11.775
No. 55	19.625

Size	Weight in Pounds
of	per
Bars	Foot
No. 2	0.167
No. 3	0.376
No. 4	0.668
No. 5	1.043
No. 6	1.502
No. 7	2.044
No. 8	2.670
No. 9	3.400
No. 10	4.303
No. 11	5.313
No. 14S	7.650
No. 18S	13.600

The computed weight will not include the extra metal used when bars larger

than those specified are substituted by the Contractor with the permission of the Engineer, the extra metal necessary for splices when bars shorter than those specified are substituted with the permission of the Engineer, or the weight of any devices used to support or fasten the steel in correct position, the weight of the epoxy coating or the weight of specified test bars.

Tie bars in pavement, between pavement and curbs, dowel bars in load transmission devices for pavement, and marginal bars in pavement, when required, will not be measured for payment. Reinforcement bars required for concrete piles or other reinforced concrete work in structures, where the concrete is not measured for payment in cubic meter (cubic yards), will not be measured for payment, but shall be considered as part of the piles or other complete units that are to be paid for as such. If the weight of the reinforcement per unit of measurement is increased from that shown on the plans, by authority of the Engineer, the additional weight of the steel will be measured for payment.

**508.08** Basis of Payment. Reinforcement bars in special reinforced pavement designs and in reinforced concrete structures where the concrete is paid for at a unit price per cubic meter (cubic yard), furnished and incorporated in the work according to the specifications, will be paid for at the contract unit price per kilogram (pound) for REINFORCEMENT BARS or REINFORCEMENT BARS, EPOXY COATED.

## **SECTION 509. METAL RAILINGS**

**509.01 Description.** This item shall include the furnishing of all materials and the necessary labor to construct and erect the completed railing of the type specified. The line and grade of the railing shall be true to that shown on the plans and not follow any defects in the superstructure. When the bridge is on a grade, railing posts, panels and openings shall be vertical except that posts for low metal railings on concrete parapets shall be normal to the parapet. Tops of railings shall be parallel to grade line.

**509.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 - Materials:

	Item	Article/Section
(a)	Structural Steel	
(b)	Lead Plates	1006.23
(c)	Paint Materials and Mixed Paints	
(d)	Steel Pipe	
(e)	Aluminum for Railings	
(f)	Stainless Steel Hardware for Railings	1006.31
(g)	Fabric Bearing Pads	1082.01
(h)	Steel Posts for Railings	1006.34(a)
(i)	Tubular Steel Rail for Railings	1006.34(b)
(j)	Steel Shapes and Plates for Railing	1006.34(c)
(k)	High-Strength Steel Bolts, Nuts and Washers	1006.08

#### CONSTRUCTION REQUIREMENTS

**509.03 Steel Railings.** Steel railings shall be fabricated, inspected, stored and erected according to Section 505 except that galvanized tubular railing and accessories shall be stored according to Article 1006.34. When painting is required, the cleaning and painting shall be according to Section 506. Galvanized railing shall not be painted.

The longitudinal rail members shall be neatly cut to fit at the steel posts as may be required by the plans. All weld areas shall be ground smooth in the shop. The rails shall be straight and true to line, without kinks, bends or warps, and shall be straightened as may be necessary before shipment.

When rail is specified to be painted, shop painting shall consist of one coat of paint.

After erection, the steel railings shall be cleaned to remove dirt, oil, grease or other foreign material.

When rail is specified to be painted, field painting shall consist of spot painting, followed by 2 complete coats of field paint applied to all accessible surfaces of the steel railings. Spot painting shall consist of one coat of shop paint applied to the heads and nuts of all field bolts, including anchor bolts, and to all areas from which the shop coat of paint has become abraded or otherwise damaged or removed.

**509.04 Aluminum Railings.** The materials for aluminum railings shall be aluminum alloy conforming to Article 1006.30. Care shall be taken to avoid scratching, denting or other defects that may affect the durability or appearance of the railing.



**509.05** Tubular Thrie Beam Retrofit Rail. The Tubular Thrie Beam rail section shall be fabricated by welding 2 Thrie Beam rail elements according to the details shown on the plans. The Thrie Beam rail section shall conform to the requirements of AASHTO M 180, Type 1, of the class specified.

All structural steel shapes and plates shall conform to AASHTO M 270 Grade 36 and shall be galvanized after fabrication according to AASHTO M 111 and ASTM A 385.



The Contractor shall load test 5% of the epoxy grouted M26 (1 inch) diameter threaded anchor rods in the presence of the Engineer. The equipment and method used shall meet the approval of the Engineer. Pull out load shall be 33 N (7400 lbs.) per rod after the epoxy has set. For each anchor that fails the test, 2 more anchors selected by the Engineer, shall be tested. Each anchor that fails shall be reset in epoxy and retested until it passes the test. Epoxy grouting of anchor rods shall be according to the requirements of Section 584.

The standard length for a Tubular Thrie Beam section is 7.5 m (25 ft.-0 inches). Posts shall be provided at standard 2.5 m (8 ft.-4 inches) centers whenever practical.

Posts shall not be located closer than 375 mm (1 ft.-3 inches) to an existing bridge expansion joint or end of bridge.

In the event that standard lengths of Tubular Thrie Beam cannot be longitudinally positioned to meet the requirements, shorter custom fabricated section(s) will be specified. When necessary to use custom length sections of Tubular Thrie Beam, the

minimum length shall be 750 m (2 ft.-6 inches) with the hole spacing for joints the same as the full length sections.

Three steel shims per post [1 at 3 mm (1/8 inch) and 2 at 1.5 mm (1/16 inch)] shall be provided for 25% of the posts. Shims shall be similar to base plate in size and holes.

All splice bolts shall be M16 (5/8 inch) diameter unless otherwise noted.

Tubular Thrie Beam expansion joint shall be provided between any 2 posts which span a bridge expansion joint. Bolts located at expansion joints shall be provided with locknuts or double nuts and shall be tightened only to a point that will allow Tubular Thrie Beam movement.

The expansion joint width shall be 65 mm (2 1/2 inches) at 10 °C (50 °F.) and shall be adjusted for other temperatures according to the requirements of Article 503.10(c).

- **509.06 Method of Measurement.** Railings will be measured in meters (feet). The length paid for will be the overall length along the top longitudinal railing member through all posts and gaps.
- **509.07 Basis of Payment.** Aluminum railing of the type specified will be paid for at the contract unit price per meter (foot) for ALUMINUM RAILING, which price shall include all materials, fabrication, transportation and erection.

Steel railing of the type specified will be paid for at the contract unit price per meter (foot) for STEEL RAILING, which price shall include all materials, fabrication, transportation, erection, cleaning, and painting.

Tubular Thrie Beam rail will be paid for at the contract unit price per meter (foot) for TUBULAR THRIE BEAM RETROFIT RAIL FOR BRIDGES, which price shall include all materials, fabrication, transportation, and erection.

## **SECTION 510. PIPE HANDRAIL**

- **510.01 Description.** This work shall consist of furnishing and erecting handrail where all posts and railing members are to be constructed exclusively with pipe.
- **510.02 Materials.** Materials shall meet the following requirements of the following Articles of Section 1000 Materials:

	Item	Article/Section
(a)	Steel Pipe	1006.18
(b)	Malleable Iron Fittings .	1006.16
(c)	Paint	

#### **CONSTRUCTION REQUIREMENTS**

**510.03 Shop Drawings.** When details are not fully shown on the plans, the Contractor shall submit duplicate copies of detailed shop drawings to the Engineer for approval before fabrication is begun. Design details shall meet the following requirements:

The railings shall be "Standard Weight" pipe and the posts "Extra Strong" pipe. Either welded or seamless pipe may be used. Rail panel lengths shall not exceed 2.1 m (7 ft.) center-to-center of posts for 40 mm (1 1/2 inch) pipe and 2.4 m (8 ft.) for larger diameter pipe. Provisions for expansion shall be made so that no railing will be continuous for more than 12 m (40 ft.) without expansion joints. Generally, the railing shall not be fixed at both sides of more than 3 successive posts. Provision for expansion shall also be made in any panel across an expansion joint in the structure to which the handrail is attached.

At all points except expansion joints, connections of railings to posts shall be made either by the use of fittings or by continuous welding without fittings. Only one type of connection shall be used in the railings for any structure. All fittings shall be of the standard ball type.

When connections are made with fittings, end and corner posts shall be in one piece and pinned, riveted or welded to intermediate fittings through which the posts pass. Intermediate and expansion posts shall be in separate pieces, threaded or welded into fittings. Rails shall be continuous through fittings at intermediate posts where expansion is not provided, and shall be pinned, riveted or welded to the fittings. Rails shall be threaded or welded into fittings at end and corner posts and shall have slip connections into fittings at all points where expansion is provided.

When connections at posts, where expansion is not provided, are made by continuous welding, slip connections of railings into fittings or other approved means of providing for expansion shall be used at expansion posts.

The pipe handrail shall be fastened to the concrete or other support by means of standard flange plates with 4 anchor bolts each, or by other equally effective means approved by the Engineer. Anchor bolts for this purpose shall have a diameter of not less than 16 mm (5/8 inch).

**510.04 Fabrication.** Fabrication of pipe handrail shall conform to the applicable requirements of Article 505.04. All welded joints shall be continuous welds, and all weld areas shall be ground smooth. The use of couplings or unions will not be permitted. Threads shall be right-hand where possible. On grades over 2 percent, pipe handrails shall be fabricated so that the posts will be vertical when erected.

Shop inspection of pipe handrail shall conform to Article 505.05. Marking and shipping shall conform to the applicable requirements of Article 505.07.

- **510.05 Cleaning and Painting.** Pipe handrail shall be painted with one shop coat of paint after being fabricated and 2 field coats of paint after erection. The kind and color of paint shall be as stated on the plans or as determined by the Engineer. Cleaning and painting shall conform to the requirements of Section 506.
- **510.06 Erection.** Whenever practicable, anchor bolts in concrete shall be placed before the concrete has set, otherwise, they shall be placed in holes drilled into the concrete, and all space not occupied by the bolt or anchoring devices shall be completely filled with mortar, or other suitable material approved by the Engineer. The erection of pipe handrail, including the handling and storing of materials, methods and equipment to be used shall conform to the applicable requirements of Article 505.08.

- **510.07 Method of Measurement.** Pipe handrail will be measured for payment in meters (feet) of railing in place. Railing on a curve or grade will be measured along the curve or grade.
- **510.08 Basis of Payment.** This work will be paid for at the contract unit price per meter (foot) for PIPE HANDRAIL, which price shall include all materials, fabrications, transportation, erection, cleaning and painting.

#### **SECTION 511. SLOPE WALL**

- **511.01 Description.** The slope wall shall be constructed on an approved earth bed as specified.
- **511.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 Materials:

	Item	Article/S	ection
(a)	Portland Cement Concrete		1020
(b)	Fabric Reinforcement	10	06.10

#### CONSTRUCTION REQUIREMENTS

- **511.03 General.** The methods of construction shall comply with Sections 502 and 503. Preferably, the slope wall shall be constructed in alternate sections each approximately 2.7 m (9 ft.) in width. The fabric reinforcement shall be supported 50 mm (2 inches) below the upper surface of the slope wall by concrete blocks. A clear distance of 50 mm (2 inches) shall be maintained between the fabric reinforcement and the outside face of any vertical or inclined toe or cutoff wall. The fabric reinforcement shall be continuous across all construction joints and shall extend into each section a minimum of 150 mm (6 inches) from any adjacent previously placed section. Adjacent sections of fabric reinforcement shall be lapped a minimum of 150 mm (6 inches) in all cases.
- **511.04** Curing and Protection. Equipment to be used for applying membrane curing, if used, shall meet the requirements of Article 1101.09(b).

#### 511.05 Method of Measurement.

- (a) Contract Quantities. The requirements of the use of Contract Quantities shall conform to Article 202.07(a).
- (b) Measured Quantities. Slope wall will be measured for payment in place and the area computed in square meters (square yards). In computing the quantity for payment, the dimensions used will be those established by the Engineer to conform to the elevations of the natural ground line or stream bed. The area for measurement will include the upper, sloped surface of the wall. Anchor and cut-off walls will not be measured for payment, but shall be considered as included in the contract unit price bid for slope wall.
- **511.06 Basis of Payment.** This work will be paid for at the contract unit price per square meter (square yard) for SLOPE WALL of the thickness specified, which price shall include payment for preparation of earth bed, excavation, backfilling,

disposal of surplus material, and furnishing and placing all materials, including fabric reinforcement and anchor and cut-off walls.

#### **SECTION 512. PILING**

**512.01 Description.** This work shall consist of the furnishing, driving, building up and cutting off of timber, precast concrete, metal shell cast-in-place concrete with or without reinforcement bars and steel piles.

**512.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 - Materials:

	Item	
(a)	Timber Piling	1007.08
(b)	Preservative Treatment	1007.12
(c)	Portland Cement Concrete	1020
(d)	Reinforcement Bars and Fabric	1006.10
	Structural Steel	
(f)	Paint Materials and Mixed Paints	1008.01 - 1008.23
(g)	Prestressing Steel Strand	1006.10
	Metal Shell and Sheet Piling	

#### CONSTRUCTION REQUIREMENTS

**512.03 Manufacture of Precast and Precast, Prestressed Concrete Piles.** Precast and precast, prestressed piles shall be constructed according to the requirements of Section 504, except as specified.

(a) Precast Concrete Piles. Precast concrete piles may be driven when the tests show that the concrete has attained a compressive strength of not less than 31 MPa (4500 psi), or a flexural strength of not less than 5.2 MPa (750 psi), but not less than 7 days from date of casting.

After removal of the side forms, the entire pile shall be supported for at least 7 days from the time of casting, unless the concrete has attained the strength specified in a shorter period. In no case shall the piles be subjected to any handling stresses until the concrete has attained a flexural strength of at least 4.5 MPa (650 psi) or 24 MPa (3500 psi) compressive strength.

If the plans provide for piles having an estimated length of 14 m (45 ft.) or less and the piles as cast are to have a length of more than 14 m (45 ft.), the additional weight of the longitudinal bars will be paid for at the contract unit price per kilogram (pound) for reinforcement bars. Each pile shall be cured according to Article 1020.13 until the concrete has attained the strength required at the time of driving, but for a period of not less than 7 days from the date of casting, except as stated below. Steam curing also will be permitted, provided that the method and its details meet the approval of the Engineer. During cold weather construction and when steam curing is not used, the concrete shall be protected according to Article 1020.13(e). The curing and protection shall begin as soon as each group of piles has been cast. However,

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if the forms are to be removed on the day following the casting of the piles, the application of the protective covering may be deferred until the forms are removed unless the gain in strength will be unduly retarded thereby. Permission for removal of the protective covering after it has been applied, for the purpose of removing the forms, may be granted by the Engineer if this does not result in undue cooling of the concrete, but the covering shall be replaced after the shortest possible interval of time.

The maximum allowable deviation of the longitudinal axis from a straight line drawn from the center of the tip to the center of the butt shall not exceed 5 mm (1/4 inch) per 6.5 m (25 ft.) of length of the pile.

(b) Precast, Prestressed Concrete Piles. Precast, prestressed concrete piles shall not be driven until the concrete has attained a compressive strength of not less than 35 MPa (5000 psi), but in no case less than 3 days from the date of casting.

The prestressing strand shall have a minimum breaking strength for 11 mm (7/16 inch) strand of 138 kN (31,000 lbs.) and a minimum load at one percent extension of 117 kN (26,350 lbs.) with an initial load of 14 kN (3,100 lbs.). The prestressing load applied to the strand shall be 96.5 kN (21,700 lbs.). Each reel of strand and all samples furnished to the Engineer for testing shall bear a tag identifying the strand as extra high-strength.

Each end of the piles shall have extra reinforcement as shown on the plans. All prestressing strands shall be ground flush with each end of the pile. The piles shall be constructed to a tolerance of 0 to +12 mm (+1/2 inch) of the cross sectional dimensions shown on the plans. The tolerance from a straight line along the longitudinal axis shall be the same as specified for precast concrete piles.

(c) Extensions or "Build-ups". Extensions, splices or "build-ups" on precast or precast, prestressed concrete piles, shall be avoided wherever possible; but when necessary, they shall be made as follows:

After driving is completed, the concrete at the end of the pile shall be cut away, leaving the reinforcement exposed for a length of 30 diameters of the bars for precast concrete piles and the prestressing strand exposed for a minimum length of 600 mm (24 inches) for precast prestressed concrete piles. The final cut shall be perpendicular to the axis of the pile. Reinforcement similar to that used in the pile shall be lapped 30 diameters and fastened to the projecting steel for precast concrete piles. Reinforcement as shown on the plans shall be lapped a minimum of 600 mm (24 inches) with the projecting prestressing strands for precast, prestressed concrete piles. In placing the form work for the extension, care shall be taken to avoid leakage along the pile. Prior to placing the concrete, the top of the pile shall be thoroughly wetted and covered with a thin coating of 1:2 cement mortar.

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**512.04 Metal Shell Cast-in-Place Concrete Piles.** Metal shell cast-in-place concrete piles shall consist of concrete encased in a steel shell which is left in place.

- (a) Metal Shells. All shells shall have the structural capacity to permit driving without distortion. Metal shells may be spliced provided that the minimum unspliced length of pile is 3 m (10 ft.). A maximum of 3 shop or field splices will be allowed in any single pile for the authorized furnished length. Splicing shall be accomplished by a full butt weld. When the splice occurs in the footing or below, an approved commercial splicer may be used. Welder certification is not required for splicing metal shells. Material certification shall be furnished by the Contractor for each section of pile used in making the required splice.
- (b) Inspection of Shells After Driving. The Contractor shall have available at all times a suitable light, of a type approved by the Engineer, for illuminating the interior of pile shells for their entire lengths after being driven. Any shell that is not watertight or that shows bends, kinks, or other deformations during the process of driving, that would impair the strength or efficiency of the completed pile, shall be either removed and replaced, or repaired by the Contractor, in a manner satisfactory to the Engineer. The Contractor will not be reimbursed for any such shells ordered removed or replaced by the Engineer. If the shells are not filled with concrete shortly after being driven, the tops of the shells shall be sealed temporarily to prevent the entrance of water or foreign substance.
- (c) Reinforcement. Reinforcement shall be used for the concrete inside the shells when so provided by the plans. Such reinforcement shall be of the unit type, rigidly fastened together and lowered into the shell before the concrete is placed. Spurs or spacers shall be used to ensure the specified clearance for the bars.
- (d) Filling Shells with Concrete. After the metal shells have been driven, cut off and approved, and any reinforcement required has been placed in position, the shell shall be filled with Class SI Concrete conforming to Section 1020. The entire depth of concrete in the pile shall be consolidated by internal vibration. The depth of successive layers of concrete placed in the shells shall not exceed that which can be satisfactorily consolidated with the vibrating equipment used.

The shells shall be given a final inspection before they are filled with concrete and any water or foreign substance found in them shall be removed. Concrete shall not be placed in shells containing water. Whenever practicable, all the piles for any one bent, pier or abutment shall have been completely driven before any concrete is placed in the shells. If this is impracticable, driving of remaining piles shall be deferred until the concrete in all shells which have been filled has been in place for not less than 24 hours from the time placing is completed. The concrete shall be protected against low temperatures as required in Article 1020.13.

#### 512.05 Steel Piles.

(a) Description. Steel piles shall consist of structural steel shapes of the sections indicated on the plans or otherwise authorized by the Engineer.

- (b) Splices and Caps. Splices will be allowed when shown on the plans or approved by the Engineer. No pre-planned field or shop splice will be allowed in piles less than 8 m (25 ft.) in length. No more than one pre-planned field or shop splice will be allowed in piles less than 12 m (40 ft.) in length. Splices shall develop the full structural capacity of the net cross section area of the pile. Splicing shall be accomplished by full penetration butt welding of the entire cross-section, by the Department's standard steel pile field splice, or by the use of an approved commercial splicer. Welder qualification and certification will be required for all splices according to Article 512.07. If steel caps are required by the plans, the piles shall be cut off evenly prior to placing the caps. Splices shall be made according to the details shown on the plans or as approved by the Engineer.
- (c) Field Connections for Trestle Bents. Connections of caps and bracing members shall be made by machine bolts or by welding according to the details shown on the plans.

When piles are not driven sufficiently exact to line up the faces of pile flanges with bracing members, fills or shims shall be furnished and placed by the Contractor to secure proper alignment of the bracing. The weight of such fills and shims will not be included in the weight of any structural steel for which the Contractor is to be paid.

- (d) Painting. Before being driven or placed, all steel piles, caps, splices and bracing members in trestle bents shall be shop painted with inorganic zinc-rich primer. When specified, after the piles are driven and all bracing members, concrete caps and encasement are in place, all exposed steel shall be given one complete coat of field paint. All painting shall conform to Section 506. Foundation piles shall not be painted.
- (e) Metal Shoes. When specified, steel H-piles shall be fitted with pile points of the design specified.

The pile points shall be cast in one piece steel conforming to ASTM A 27M (A 27) (Grade 65-35). They shall have sufficient flange and continuous web vertical back-ups to assure proper alignment and fitting to the pile. They shall provide full bearing for the piles and shall be fastened to the piles using 8 mm (5/16 inch) continuous fillet weld along the flange contact areas. The soil or rock bearing surfaces of the points shall be sloped downward toward the web a minimum of 15° but not to exceed 30° to the horizontal under the flanges. The sloped surfaces of the points shall terminate in a manner to form a flat surface not exceeding one fourth of the flange width. These surfaces may have individual or continuous cutting teeth. The minimum mass (weight) of the pile points shall be according to the following schedule:

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<u>Pile Size</u>	Min. Mass of Point- Kg. (Lbs.)
HP 200 (HP 8)	7.0 (15)
HP 250 (HP 10)	10.0 (22)
HP 310 (HP 12)	13.0 (30)
HP 360 (HP 14)	20.0 (46)

**512.06 Splicing Timber Piles.** Where possible, full length piles shall be used. No splices may be made without the permission of the Engineer. When splices are permitted, they shall be of the butt joint type and the added piece shall conform closely in diameter to the main pile at the point of splice. The pile shall be sawed square and the butt joints shall bear evenly over the entire surface. The splices shall be made by the use of at least four steel plates or a metal pipe sleeve. The plates shall be at least 1.2 m (4 ft.) long, 90 mm (3 1/2 inches) wide and 10 mm (3/8 inch) thick and each plate shall be bolted to the pile with not less than two M20 (3/4 inch) bolts both above and below the joint. Pipe sleeves shall be standard steel pipe, at least 900 mm (3 ft.) long and shall be fastened with not less than three M16 (5/8 inch) lag screws, 125 mm (5 inches) long, both above and below the joint. All metal used for splicing creosoted piles shall be painted one coat of a metal protective paint approved by the Engineer. If exposed, the metal shall also be given two coats of field paint of an approved color.

Before the splice is assembled, if the joint is to be above low ground water line, all sawed surfaces and holes in creosoted and untreated piles shall be treated as provided in Article 1007.12(f).

**512.07 Welding.** All welding shall conform to the applicable requirements of Article 505.04(k). A welder may be qualified for fillet welds on steel piles by welding a test specimen according to the requirements of the Qualification Test for Fillet Welds Only (Option 1) of the AWS Specifications, except that the requirements for the macroetch specimen will be waived.



Welding will be permitted in all cases for splicing metal shells. Welder qualification requirements will be waived for splicing of metal shells. Welding shall be used for splicing steel piles and for attaching bracing or other steel members to steel piles, when specified.

#### 512.08 Storage and Handling of Piles.

- (a) General. The method of storing and handling all piles shall be such as to avoid damage to the piles.
- (b) Creosoted Timber Piles. Creosoted timber piles shall be stored at the site of the work according to Article 1007.12(f) and handled as specified in Articles 507.05 and 1007.12(f).
- (c) Precast and Precast, Prestressed Concrete Piles. Removal of forms, curing, storing, transporting, and handling precast and precast, prestressed concrete piles shall be done in such a manner as to avoid excessive bending stresses, cracking, spalling or other injurious effects. In general, precast concrete piles shall be lifted by suitable

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devices attached to the pile at not less than 2 points for piles up to 14 m (45 ft.) long, and not less than 3 points for piles over 14 m (45 ft.) long. Precast prestressed concrete piles shall be lifted by suitable devices and supported during storage or transportation at not less than 2 points for piles up to 20 m (65 ft.) long and not less than 3 points for piles over 20 m (65 ft.) long. The locations of the points of support shall be as shown on the plans.

The piles may be lifted by a bridle attached to the pile or special embedded or attached lifting devices as approved by the Engineer. Unless special lifting devices are attached for lifting, the pickup points shall be plainly marked on all piles before removal from the casting bed and all lifting shall be done at these points. Deviation from the above method of handling will be permitted, subject to the approval of the Engineer. The method of handling precast concrete piles shall not induce stresses in the reinforcement in excess of 80 MPa (12,000 psi), allowing 100 percent of the calculated load for impact and shock. The method of handling precast prestressed concrete piles shall not induce tensile stresses in the concrete in excess of 1.4 MPa (210 psi), allowing 100 percent of the calculated load for impact and shock.

(d) Steel Piles. The handling and storing of steel piles shall be done according to the provisions of Article 505.08(c).

512.09 Preparation for Driving. Foundation piles shall not be driven until after the excavation for the footings is completed. Any material forced up between the piles shall be removed to the correct elevation before concrete in the foundation is placed. Trestle piles and piles for abutments shall not be driven until any required channel excavation or excavation for backing and bracing is completed, at least at the location of the piles.

- (a) Pointing Timber Piles. When necessary, timber piles shall be pointed for driving. Retreatment of the pointed area will not be required. When specified, the piles shall be shod with metal shoes of a design satisfactory to the Engineer. The points of the piles shall be shaped to secure an even and uniform bearing on the shoes.
- (b) Precast Concrete Piles. If the piles have been allowed to dry after curing, the entire pile shall be saturated at least 6 hours prior to driving.

**512.10 Driving Piles.** The equipment for driving piles shall be adequate for driving piles 3 m (10 ft.) longer than the longest plan length shown on the plans. The equipment shall be capable of driving the entire length of pile without splicing. The use of a shorter length of equipment or the use of preplanned splices shall meet the approval of the Engineer. The pile hammer shall meet the approval of the Engineer. The equipment and methods for driving piles shall conform to the following requirements:

(a) Methods of Driving. Piles shall be driven with a gravity, steam, compressed air, or diesel hammer. Hydraulic hammers may be used with written approval of the Engineer. If a hydraulic is allowed, the Contractor shall furnish, at his/ her expense, wave equation analysis and a pile driving analyzer to aid in the determination of the adequacy of the hammer and the bearing capacity of the pile. The use of jets

or other methods of pile driving shall meet the approval of the Engineer. The driving of each pile shall be continuous until the pile has attained the specified bearing capacity. The method of driving shall not result in damage to the pile.

(b) Caps, Helmets and Driving Heads. The heads of timber piles shall be protected by a cap during driving. The cap shall consist of a cushion made of wood. The design of the cap shall meet the approval of the Engineer.

The heads of steel piles shall be protected by a cast or structural steel helmet. The helmet shall be capable of holding the axis of the pile in line with the axis of the hammer and prevent damage to the pile during driving.

The heads of metal shell pile shall be protected by a combination driving head and pilot capable of distributing the hammer blow uniformly across the metal shell cross section and maintaining the alignment of the pile.

The heads of precast concrete and precast, prestressed concrete piles shall be protected by a cushioned driving head during driving to prevent damage to the pile.

(c) Driving Piles through Embankment. When called for on the plans, holes shall be precored for timber and for precast, precast prestressed, or cast-in-place concrete piles which are to be driven in an embankment area. After the embankment has been constructed, holes shall be drilled at proper locations through the embankment to the natural ground level and the piles shall be driven through these holes. If oversize holes are drilled, the void space outside of the pile shall be filled with dry loose sand.

Test piles may be driven before the embankment is placed, or they may be driven through the precored embankment as herein specified.

The cost of complying with these requirements will not be paid for separately but shall be considered as included in the unit prices bid for the pay items involved.

(d) Hammers for Timber Piles. Gravity hammers for driving timber piles preferably shall weigh not less than 13.3 kN (3000 lbs.), but lighter hammers may be used provided the minimum weight of the hammer is 9 kN (2000 lbs.) for required pile capacities of 142 kN (16 tons) or less, 11 kN (2500 lbs.) for required pile capacities of more than 142 kN (16 tons) but not more than 178 kN (20 tons), and 13.3 kN (3000 lbs.) for required pile capacities of more than 178 kN (20 tons) but not more than 222 kN (25 tons). The capacity of the piles as stated on the plans shall be used in determining the minimum weight of drop hammer permitted. The fall of the hammer shall be regulated so as to avoid injury to the piles, but shall in no case exceed 6 m (20 ft.), and shall be between 4.3 m (14 ft.) and 4.8 m (16 ft.) at the time that the capacity is being determined as specified in Article 512.14(b). The Contractor shall establish the true weight of the hammer used on the

- work to the satisfaction of the Engineer. Steam, air or diesel hammers used for driving timber piles shall develop an energy of not less than 8100 J (6000 ft.-lbs.) per blow.
- (e) Hammers for Precast and Precast, Prestressed Concrete Piles. Precast and precast, prestressed concrete piles shall be driven with a steam, air or diesel hammer. The hammer shall develop an energy per blow sufficient to achieve the required pile capacity with not more than 10 blows per 25 mm (1 inch) at the final set.
- (f) Hammers for Metal Shell Cast-in-Place Concrete Piles. Pile shells shall be driven with a steam, air or diesel hammer which shall develop an energy per blow sufficient to achieve the required pile capacity with not more than 10 blows per 25 mm (1 inch) at the final set.
- (g) Hammers for Steel Piles. Steel piles shall be driven with a steam, air or diesel hammer which shall develop an energy per blow of not less than that calculated in the following manner:
  - (1) Single acting steam or air hammers and open type diesel hammers
    - \*\*\* WH = 35P (WH = 0.1P)
  - (2) Double acting steam or air hammers and closed type diesel hammers
    - \*\*\* E = 35P (E = 0.1P)
  - (3) \*\*\*Where:
    - E= Energy in joules (foot pounds) per blow of striking parts of hammer.
    - H= Height of fall, millimeters (feet).
    - P= Safe allowable bearing value of piles in kilonewtons (pounds) when driven vertically. For piles driven to design capacity, use capacity from plans in kilonewtons (pounds). For piles specified to be driven to refusal, use P = 1.5 (.062 x mm<sup>2</sup> pile cross section) [P = 1.5 (9000 x sq. inch pile cross section)].
    - W = Force (Weight) of striking parts of hammer in kilonewtons (pounds).
- (h) Leads. Pile leads shall be used to maintain the alignment of the pile. Leads may be either fixed or swinging. Swinging leads shall be set or toed in the ground prior to the start of driving. The design of the leads shall accommodate the full length of pile, hammer and other required equipment and be capable of maintaining the alignment of the pile during driving within the tolerances specified.
- (i) Followers. The driving of piles with followers shall be done only with the written permission of the Engineer. When followers are used, one pile in every group of 10 shall be driven without a follower, by using a longer pile if necessary, and shall be used, in effect, as a test pile to

- determine the average bearing capacity of the group. This pile will be paid for as a permanent pile and not as a "test pile".
- (j) Jets. Water and air jets shall be used when approved by the Engineer. The jets shall have the capacity to erode the material adjacent to the pile. Unless cast inside of concrete piles, the jets shall be free to move along the axis of the pile. The use of jets shall be discontinued before final set is reached. Unless otherwise approved by the Engineer, the piles shall be driven with the hammer for the final 600 mm (2 ft.) of penetration after use of the jets has been discontinued.
- **512.11 Penetration of Piles.** All piles shall be driven to a penetration such that the bearing value, as determined by the formulas in Article 512.14(b), is not less than that indicated on the plans.

Foundation piles shall be driven to a penetration of at least 3 m (10 ft.) below bottom of footing, and other piles to a penetration of at least 3 m (10 ft.) below undisturbed earth. Piles in stream beds or on the banks of streams, where marked erosion is expected, shall be driven to such penetration as the Engineer deems necessary as protection against scour.

If, after a test pile is driven through and below a hard stratum, the bearing value of the test pile drops below the capacity required by the plans, the Engineer may require the Contractor to drive the permanent piles through the hard stratum to a penetration at which the required capacity is again obtained.

Except as required above, and as otherwise required for test piles, the Contractor will not be required to drive any pile to a bearing value of more than 45 kN (5 tons) in excess of the bearing value required by the plans.

When production friction piles fail to achieve plan bearing capacities after driving the full finished lengths, these piles, when approved by the Engineer, can be left for a minimum of 24 hours to allow for soil setup before attempting to splice. After the waiting period has passed, the Contractor shall redrive one representative pile in each group of such piling to check the gain in bearing upon soil setup. The soil setup bearing shall be based on the number of redriving blows necessary to drive the pile an additional 75 mm (3 inches). These piles may be accepted without splicing if they exhibit sufficient bearing capacity.

- **512.12 Tolerances in Driving.** Foundation piles shall be driven with a variation from the vertical or from the required batter of not more than 10 mm/m (1/8 inch per ft.). Piles supporting caps or having bracing or backing attached to them shall be driven with sufficient accuracy in position and alignment so that, without injury to the piles by forcing them into correct position after driving, no pile is out of correct position at the base of the cap by more than 25 mm (1 inch) in any direction; or out of alignment by more than 50 mm (2 inches) at the bottom of the backing or bracing, or at the ground line if the latter is lower or if there is no backing or bracing. All piles seriously damaged in driving or driven out of position shall be pulled or cut off, as the Engineer may direct, and shall be replaced satisfactorily by the Contractor at his/her own expense.
- **512.13 Cutoffs.** The tops of all piles shall be cut off perpendicular to the longitudinal axis of the pile at elevations established by the Engineer. Piles which support timber caps or grillages shall be sawed to conform to the plane of the

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bottom of the superimposed structure. In all cases, the amount of cutoff shall be sufficient to remove any portion of the pile top trimmed for driving or bruised during driving. All debris shall be removed from around the pile heads.

The heads of all creosoted timber piles, when not encased in concrete, shall be given three coats of a hot mixture of 60 percent creosote oil and 40 percent roofing pitch, or given three brush coats of hot creosote oil and covered with roofing pitch. Each pile head shall then be covered with a sheet of galvanized iron, not lighter than 0.701 mm (24 gage) and of sufficient area to project at least 100 mm (4 inches) outside the pile at any point, which shall be bent down over the pile to fit neatly and exclude water in the best possible manner. The edges shall be trimmed neatly and fastened to the pile face with large headed galvanized roofing nails.

The cutoff portions of all piles, including test piles, shall be retained and made available for use in splicing or building up piles if required until the pile driving is complete. Upon completion of the work, the cutoffs shall become the property of the Contractor and shall be disposed of by the Contractor at his/her expense.

- **512.14 Determination of Bearing Values.** The bearing values will be determined by one of the following methods:
  - (a) By Loading Tests. When provided for on the plans or so ordered by the Engineer, the Contractor shall load one or more piles of a group to determine their safe bearing values. The pile load test shall be performed according to ASTM D 1143.
    - For piles driven by methods other than specified in Article 512.10(a), the Contractor will be required to determine the bearing value of the piles by loading tests as specified.
  - (b) By Formulas. If loading tests are not required, the following formulas will be used as a guide to determine the safe bearing values for piles driven in a vertical position:

For timber and steel piles and metal shells for cast-in-place piles:

#### Metric Formulas

$$P = \frac{WH}{6(S+25.4)}$$

for gravity hammers

$$P = \frac{WH}{6(S+2.54)}$$

for single acting steam or air hammers, and open type diesel hammers;

$$P = \frac{H(W+Ap)}{6(S+2.54)}$$
 or  $= \frac{E}{6(S+2.54)}$ 

for double acting steam or air hammers, and closed type diesel hammers

For precast and precast prestressed concrete piles:

$$P = WH \over 6(S+2.54\underline{w}) W)$$

for single acting steam or air hammers, and open type diesel hammers

for double acting steam or air hammers, and closed type diesel hammers

## **English Formulas**

$$P = 2 WH$$
S+1.0

for gravity hammers

for single acting steam or air hammers, and open type diesel hammers;

$$P = {2H(W+Ap) \over S+0.1}$$
 or  $= {2E \over S+0.1}$ 

for double acting steam or air hammers, and closed type diesel hammers

For precast and precast prestressed concrete piles:

$$P = \underbrace{\frac{2 \text{ WH}}{\text{S+0.1} \underline{\text{W}}}}_{\text{W}}$$

for single acting steam or air hammers, and open type diesel hammers;

$$P = \underbrace{\frac{2H(W+Ap)}{S+0.1\underline{w}}}_{W} \text{ or } = \underbrace{\frac{2E}{S+0.1\underline{w}}}_{W}$$

for double acting steam or air hammers, closed type diesel hammers Piling Art. 512.14

For piles driven to a batter, the safe bearing value of the pile along its axis will be taken as U times P, the value of U being determined as follows:

$$U = \frac{0.25(4-m)}{(1+m^2)^{0.5}}$$
 for gravity hammers

In the above formulas in this Article,

P = safe allowable bearing value of piles, in kilonewton (pounds) when driven vertically;

W = weight of striking parts of hammer, in kilonewton (pounds)

w = weight of pile, in kilonewton (pounds)

H = height of fall, in millimeter (feet)

A = area of piston, in square millimeters (square inches)

 p = mean effective steam or air pressure in cylinder of hammer, in kiloNewton per square millimeter (pounds per square inch)

E = energy of the striking parts of the hammer, in joules (foot-pounds)per blow

S = average penetration, in millimeters (inches)
per blow, for 5 to 10 consecutive blows
for gravity hammers, or 10 to 20 consecutive blows for steam or air
hammers and diesel hammers:

m = tangent of the angle of batter;

U = a coefficient, less than unity.

1 kg = 0.00981 kN

The Engineer will determine the value of "E", effective energy, of closed type diesel hammers, the effective energy being the energy developed by the compressed air and/or gas in the upper chamber plus the energy developed by the falling ram. All necessary gages and/or instruments shall meet the approval of the Engineer and they shall be furnished and properly installed by the Contractor who shall also furnish the Engineer with the specifications of the hammer that will be used to perform the work. No additional compensation will be allowed the Contractor for furnishing and installing the gages and/or instruments nor for furnishing the hammer specifications.

The preceding formulas for piles driven with a gravity hammer are applicable only when: the hammer has a free fall; the pile head is not broomed, crushed or splintered; there is no appreciable bounce of the hammer after striking the pile; the penetration is at a uniform or uniformly decreasing rate; and the average

penetration of 5 consecutive blows is not less than 25 mm (1 inch) per blow under a free fall of the hammer.

When the penetration of a pile is almost wholly obtained by the use of jets, a hammer being used merely as an aid to force the pile into place and to secure the final 600 mm (2 ft.), more or less, of penetration, the preceding formulas will not be used to determine the safe bearing value of the pile. For such jetted piles, the safe bearing value will be determined by actual loading tests as specified in paragraph (a) of this Article, unless, in the opinion of the Engineer, the pile will develop a safe frictional resistance.

512.15 Test Piles. When required by the plans, the Contractor shall furnish and drive test piles at locations determined by the Engineer. These piles shall be 3 m (10 ft.) longer than the length of the permanent piles shown on the plans. When so instructed by the Engineer, the Contractor shall drive each test pile to refusal or to a capacity 50 percent greater than the capacity of any pile, the penetration of which is to be determined by the test pile. H-piles specified for refusal bearing shall be driven to refusal bearing P as defined in Article 512.10(g). Test piles shall be of the same material and size as the permanent piles, except that, if creosoted piles are specified, untreated piles may be used by written permission of the Engineer, if not driven in a permanent location or within any footing area. If metal shoes are required on permanent piles, the test piles shall be provided with metal shoes of the same kind. Steel test piles driven in a permanent location shall be painted as specified for permanent steel piles. Test piles shall be driven with the same equipment as will be used for driving the permanent piles. Before driving test piles, the excavation shall be completed to an elevation not more than 600 mm (2 ft.) above the proposed grade at the point where a test pile is to be driven except when piles are specified to be driven to point bearing. Test piles driven as permanent piles shall be cut off as permanent piles. Test piles not driven in a permanent location shall be cut off or pulled, as directed by the Engineer.

The bearing capacity of each test pile will be determined according to Article 512.14 and the lengths of the permanent piles to be furnished will be determined by the Engineer from these test piles.

- **512.16 Length of Piles.** The Contractor shall furnish pile lengths according to a written itemized list provided by the Engineer. Should the Contractor elect to preorder piles prior to being furnished with the itemized list, it will be at his/her own risk. All costs associated with driving and splicing preordered piles that are shorter than the authorized furnished length shall be at the Contractor's expense. The authorized furnished length will be based on the Engineer's evaluation of the test pile results. If the plans do not require a test pile, the ordered length shall be as noted on the plans.
- **512.17 Method of Measurement.** Piling will be measured for payment in the following manner:
  - (a) By Number. Test piles, pile test loadings and metal shoes will be measured by determining the number of each of these items.
  - (b) By Length. Furnishing and driving piles; furnishing, driving, and filling metal shells for cast-in-place concrete piles and cast-in-place concrete pile extensions will be measured in meters (feet). Measurement of lengths will be made to the nearest 0.1 m (0.1 ft.).

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(c) By Volume. Concrete encasement will be measured in cubic meters (cubic yards) according to Article 503.21.

# **512.18 Basis of Payment.** Payment for piling will be made in the following manner:

(a) Furnishing Timber Piles. This work will be paid for at the contract unit price per meter (foot) for FURNISHING UNTREATED PILES and for FURNISHING CREOSOTED PILES. Payment will be made for the total number of meters (feet) of all piles which have been delivered to the site of the work, according to the itemized list furnished by the Engineer, and additional lengths ordered by the Engineer, and which have been accepted.

If a pile is furnished in a length different from the plan length but the length as furnished is within a length range for which a unit price is provided in the contract, that pile will be paid for at the contract unit price for piles of that length range. If the length of a pile as furnished is not within a length range for which a price is provided in the contract, payment for that pile will be made at a unit price determined by multiplying the contract unit price for the length of that pile as shown on the plans by the percentages given in the following tables:

	UNTREATED PILES											
Length Range of Pile	Percent	age of Contract U	nit Price									
Shown in Contract meters (feet)	Length Furnished Up to 9 m (30 ft.)	Length Furnished 9.1 m to 14 m (30.1 to 45 ft.)	Length Furnished Over 14 m (45 ft.)									
Up to 9 (30) 9.1 (30.1) to 14 (45) Over 14 (45)	100 90 85	115 100 95	125 110 100									



	CREOSOTED PILES										
Length Range of Pile	Percenta	age of Contract U	nit Price								
Shown in Contract, meters (feet)	Length Furnished Up to 6.0 m (20 ft.)	Length Furnished 6.1 m to 11.5 m (6.1 to 38 ft.)	Length Furnished Over 11.5 m (38 ft.)								
Up to 6.0 (20) 6.1 (20.1) to 11.5 (38) Over 11.5 (38)	100 90 85	115 100 95	125 110 100								

The unit price per meter (foot) as provided in the contract or as above determined will be payment in full for furnishing the piles at the site of the work. No payment will be made for falsework piles or for splices and extensions which are made necessary by damage during driving.

- (b) Furnishing Precast Concrete, Precast, Prestressed Concrete, Metal Shell and Steel Piles. This work will be paid for at the contract unit price per meter (foot) for FURNISHING **PRECAST** CONCRETE PILES. **FURNISHING PRECAST** PRESTRESSED CONCRETE PILES, FURNISHING METAL PILE SHELLS and FURNISHING STEEL PILES of the size designated. Payment will be made for the total number of meters (feet) of all piles which have been delivered to or manufactured at the site of the work according to the itemized list furnished by the Engineer, and which have been accepted. This length will include additional lengths ordered by the Engineer and accepted, and "build-ups", except those for which payment for furnishing is provided in Article 512.18(f). The length of a "build-up" will include the length required to replace that portion of the main pile which is cut off in making the extension. No payment will be made for "build-ups" made necessary by damage to the piles during driving. The contract unit price per meter (foot) for furnishing steel piles shall include furnishing steel caps, if shown on the plans.
- (c) Driving Timber, Precast Concrete, Precast, Prestressed Concrete and Steel Piles and Driving and Filling Metal Shells for Cast-in-Place Concrete Piles. This work will be paid for at the contract unit price per meter (foot) for DRIVING TIMBER PILES, DRIVING PRECAST CONCRETE PILES, DRIVING PRECAST, PRESTRESSED CONCRETE PILES, DRIVING STEEL PILES and DRIVING AND FILLING SHELLS, subject to the following terms and conditions.

Payment will be made for the total number of meters (feet) of all piles left in place. For timber, metal shell and steel piles, this length will include the length of all extensions below the cutoff. For precast and precast, prestressed concrete piles, this length will include the length of all "build-ups", but not the portion cut off for making the splice. The contract

unit price will include payment for furnishing and placing concrete and reinforcing bars when required, in metal pile shells, and payment for erecting caps, if specified, for steel piles. No payment will be made for cutoffs, treatment of pile heads, defective shells or for driving falsework piles.

- (d) Furnishing Concrete Piles. The piles furnished under this item shall be either Precast Concrete, Precast, Prestressed Concrete or Metal Shell Cast-in-Place Piles. The selection of the type of pile to be used shall be at the option of the Contractor from among those shown on the plans as alternates. This work will be paid for at the contract unit price per meter (foot) for FURNISHING CONCRETE PILES. The length paid for will be as specified in Article 512.18(b).
- (e) Driving Concrete Piles. This work will be paid for at the contract unit price per meter (foot) for DRIVING CONCRETE PILES. Payment will be made for the total number of meters (feet) as specified in Article 512.18(c).
- (f) Splices for Piles. No extra compensation will be allowed for splices for piles, except that, when splices are required because of the use of lengths in excess of those given in the itemized list furnished to the Contractor by the Engineer, such splices will be paid for according to Article 109.04. For timber piles, metal shells for cast-in-place concrete piles and steel piles, the extra work to be paid for will be the work involved in making the splice. For precast and precast, prestressed concrete piles, the extra work shall include the removal of the portion cut off for making the splice and the furnishing of all materials and constructing the "build-up" above the splice.
- (g) Concrete Encasement. The concrete encasement of steel piles and cast-in-place concrete piles will be paid for at the contract unit price per cubic meter (cubic yard) for CLASS SI CONCRETE ENCASEMENT, which price shall include payment for furnishing and placing the reinforcement required for the encasement and any excavation necessary to construct it.
- (h) Cast-in-Place Pile Extensions. When metal shell cast-in-place concrete piles are to be extended with a reinforced concrete section above the top of the metal shell, that portion above the top of the metal shell will be paid for at the contract unit price per meter (foot) for CAST-IN-PLACE PILE EXTENSIONS, which price will include payment for all reinforcement in the extensions and in the splices between the extensions and metal shell concrete piles. Concrete extending below the tops of the metal shells, and all reinforcement therein, will not be measured for payment but the cost will be included in the price for the extensions above the tops of the metal shells.
- (i) Test Piles. Furnishing and driving test piles will be paid for at the contract unit price each for TEST PILES, of the type designated, which price will include all work specified in Article 512.15 or otherwise required for test piles to serve as permanent piles. Piles paid for as Test Piles will not be paid for under any other item.
- (j) Loading Tests. Loading tests to determine the safe bearing value of a pile will be paid for at the contract unit price each for PILE TEST LOADING.
- (k) Metal Shoes. The furnishing of metal shoes for piles, other than test piles,

- will be paid for at the contract unit price each for METAL SHOES which price shall include payment for attaching the shoes to the piles.
- (I) When either of the following two conditions occur, the Engineer may authorize blasting and/or other work not otherwise provided for to obtain the specified penetration, and payment will be made according to Article 109.04.
  - (1) When it is specified that piles are to be driven to a predetermined bearing, and hard or firm material is encountered at locations where piles are being driven, and penetration cannot be obtained by ordinary driving and jetting as determined by the Engineer.
  - (2) When it is specified that piles are to be driven to a predetermined elevation regardless of bearing, and ledge rock or concrete which is indiscernible, or not shown on the plans, or mentioned in the Special Provisions is encountered.

#### **SECTION 513. TEMPORARY BRIDGES**

- **513.01 Description.** This work shall consist of the construction of temporary bridges, their maintenance in a safe condition for traffic, and their removal and disposal.
- **513.02 Design.** If complete plans are not furnished by the Department, the details of design, materials to be used, sizes, spacing and arrangement of members shall be determined by the Contractor and shall meet the approval of the Engineer. The highway loading, roadway width and overall length or waterway opening shall be as specified. The temporary bridge, including railings, shall be designed according to the AASHTO Standard Specifications for Highway Bridges. Temporary bridge plans furnished by the Contractor shall be sealed, attesting to their structural adequacy, by a Structural Engineer registered in the State of Illinois.
- **513.03 Materials.** All materials shall meet the requirements of Section 1000 Materials, except as modified herein. The lumber and timber used for the temporary bridge may be either new or used, and shall meet the approval of the Engineer as to quality and suitability for the use intended. Structural steel members not described by the plans shall also meet the approval of the Engineer as to quality and suitability. The outer bark shall be removed from piles in temporary bridges at points where bracing or backing is attached; otherwise, the requirements of Article 1007.08(c) concerning the removal of bark shall not apply. Hardware for temporary bridges need not be galvanized. Any paint required shall be furnished by the Contractor.

### **CONSTRUCTION REQUIREMENTS**

**513.04** Excavation and Fill. All excavation necessary for the construction of any temporary bridge, and all backfilling up to the original ground surface, shall be according to Section 502 and will not be measured for payment, except that rock excavation will be paid for as provided therein. All other excavation such as for channel changes or approach roadways to the temporary bridge shall conform to Section 200, and will be paid for separately, unless otherwise specified.

**513.05 Piling and Timber.** Except as modified herein, all work involving timber piles shall conform to the applicable requirements of Sections 507 and 512. The requirements concerning treatment of piling, treatment of holes and pile tops, and metal coverings for piles shall not apply.

Timber construction shall comply with the applicable requirements of Section 507, as determined by the Engineer. The requirements of that Section regarding the use of treated timber shall not apply. Timber shall be either rough or surfaced. Countersinking will not be required except in the vertical roadway face of wheel guards and under longitudinal floor planks.

- **513.06 Other Construction.** No painting of structural steel will be required except as specified. Temporary bridge members of precast concrete shall be according to applicable requirements of Section 504.
- **513.07 Maintenance and Replacement.** The Contractor shall maintain such temporary bridge in good condition during its period of service or until the completion of the work covered by his/her contract. All labor and materials required for such maintenance, including the repair of any damage caused by traffic, shall be furnished by the Contractor without additional compensation. After the construction of a temporary bridge has been completed, if it is damaged by flood, washed out or otherwise destroyed through no negligence of the Contractor, the cost of any necessary repairs or reconstruction will be borne by the Department.
- **513.08 Removal.** After the new construction has been opened to traffic and the need for the temporary bridge has ceased to exist, it shall be removed by the Contractor, become the Contractor's property and be disposed of by the Contractor as provided in Article 501.02. No excavation or other material will be allowed to remain in the stream channel.
- **513.09** Basis of Payment. This work will be paid for at the contract unit price each for TEMPORARY BRIDGE COMPLETE, which price shall be payment in full for the temporary bridge, including the maintenance, removal and disposal of the structure.

#### SECTION 514. TEMPORARY BRIDGE RAIL

- **514.01 Description.** This item shall consist of furnishing, constructing, painting, maintaining and removing a temporary steel bridge rail according to the details shown on the plans.
- **514.02 Materials.** Materials, including the furnishing of all posts, steel tubing, bolts, rail splices and/or devices and other accessories for fastening the posts to the bridge deck, shall conform to the applicable portions of Section 509.

#### CONSTRUCTION REQUIREMENTS

**514.03 General.** Construction requirements shall conform to the applicable portions of Section 509. The bridge rail shall receive 1 coat of a steel prime paint.

After the removal of bolts and anchorage devices, all holes in deck to remain in place shall be filled with epoxy grout flush with the deck surface. Where anchor bolts

are epoxy grouted in a deck to remain in place, after removal of the temporary bridge rail, the bolts shall be cut off flush with the deck surface.

The epoxy grout shall be a 100 percent solid, two-component, liquid epoxy-resin system that when mixed with compatible dry, sharp aggregates with angular - shaped particles will produce a high-strength grout that shall not shrink on curing. The epoxy shall be mixed and placed according to the manufacturer's recommendations.

**514.04 Basis of Payment.** This work will be paid for at the contract unit price per meter (foot) for TEMPORARY BRIDGE RAIL, measured in place, which price shall be payment in full for the temporary rail as shown on the plans, including its erection and removal for each stage of construction, painting, epoxy grout, cutting off bolts, maintenance and disposal of the bridge rail.



#### **SECTION 515. NAME PLATES**

- **515.01 Description.** This work shall consist of the furnishing and installing of name plates.
- **515.02 Materials.** Name plates shall be made of brass, bronze or other material as provided by the plans.

#### **CONSTRUCTION REQUIREMENTS**

- **515.03 General.** The general features of design, the type, size and spacing of letters and figures, the items of information to be shown on all name plates for structures constructed under a given contract and the arrangement of these items, shall conform to drawings furnished by the Department. The surface of the name plate shall be polished. The details of manufacture and provisions for attaching each name plate shall conform to the plans and be suitable for the type of structure on which it is to be installed.
- **515.04 Installation.** Each name plate shall be rigidly attached to the structure. On concrete structures, each brass or bronze name plate shall be embedded in the concrete and fastened by means of 4 brass or bronze bolts with countersunk heads, or 4 lugs cast integral with the plate. The bolts or lugs shall project at least 75 mm (3 inches) into the concrete beyond the back of the plate.

On steel truss spans, the plate shall be fastened on the steel member at the fabricating shop by brazing around the entire perimeter of the plate.

On steel rails, the plate shall be bolted on with four, M10 x 25 mm (3/8 inch x 1 inch) stainless steel or brass cap screws that are self tapping or drilled and tapped in the field.

**515.05 Basis of Payment.** Name plates will be paid for at the contract unit price each for NAME PLATES, which price shall include furnishing and mounting the name plate.

#### **CULVERTS**

#### **SECTION 540. BOX CULVERTS**

- **540.01 Description.** This work shall consist of the construction of all cast-in-place and precast concrete box culverts.
- **540.02 Materials.** Materials shall meet the requirements of Article 503.02 and Article 504.02.
- **540.03 Equipment.** Equipment shall meet the requirements of Articles 503.03 and 504.03.

#### **CONSTRUCTION REQUIREMENTS**

**540.04 General.** Concrete box culverts shall be constructed according to the applicable portions of Section 503 for cast-in-place concrete box culverts and of Section 504 for precast concrete box culverts.

The Contractor shall have the option, when a cast-in-place concrete box culvert is specified, of constructing the box culvert using precast box culvert sections when the design cover is 150 mm (6 inches) minimum. The precast box culvert sections shall be designed for the same design cover and live load shown on the plans for cast-in-place box culvert and shall be of equal or larger size opening.

The Contractor shall be responsible for diverting the water flow from the construction area using a method meeting the approval of the Engineer. The cost of diverting the water flow shall be considered as included in the contract unit price bid for the box culvert being constructed and no additional compensation will be allowed.

**540.05** Cast-In-Place Concrete Box Culverts. Concrete culvert footings shall be considered as consisting of all monolithic wingwall footings, all curtain walls below the flow line of the barrel, the base slab, and the sidewalls and wingwalls to a height of approximately 150 mm (6 inches) above the base slab.

Piling may be added or deleted from footings of culverts when the natural foundation conditions encountered make it necessary. The footings shall be redesigned, if necessary, to permit the addition of piles or to spread the footing for stable bearing.

The footings shall be placed as a monolith and allowed to set for a period of time sufficient to preclude the possibility of damage by subsequent work. In the construction of box culverts 2 m (6 ft.) or less in vertical clearance, the side walls and top slab may be constructed as a monolith in the same placing operations. When this method of construction is used, any necessary construction joints shall be vertical and at right angles to the axis of the culvert. In box culverts of sufficient size to prohibit that part above the footing being completed in one continuous operation, horizontal construction joints will be permitted wherever necessary below the floor slab. A horizontal construction joint will be required below the top slab of any culvert having vertical clearance of more than 2 m (6 ft.).

Cast-in-place concrete culvert slabs built to roadway grade shall be finished according to Article 503.17(c).

Art. 540.06 Box Culverts

**540.06** Precast Concrete Box Culverts. Precast concrete box culvert sections and end sections shall conform to the requirements of AASHTO M 273M (M 273) when the design cover is less than 600 mm (2 ft.) but no less than 150 mm (6 inches) and AASHTO M 259M (M 259) when the design cover is 600 mm (2 ft.) or greater but limited to maximum design covers shown in the tables.

Where cast-in-place headwalls and vertical cantilever wingwalls are used as shown in the contract plans, they shall be collared around the end of the precast section. Where cast-in-place horizontal cantilever wingwalls are used as shown in the contract plans, they shall be poured monolithically with at least 2m (6 ft.) of cast-in-place box section. The cast-in-place box section shall be collared around the end of the precast section. The cast-in-place collars shall be reinforced.

Shop plans for the precast concrete box culvert sections, precast or cast-in-place end sections and headwalls, and the cast-in-place collars shall be submitted according to the requirements of Article 504.04.



The excavation and backfilling for precast concrete box culvert shall be according to the requirements of Section 502 except a layer of porous granular material, at least 150 mm (6 inches) in thickness, shall be placed below the elevation of the bottom of the box. The porous granular material shall be gradation CA 18 and shall be placed to extend at least 600 mm (2 ft.) beyond each side of the box. The precast concrete box culvert shall be laid according to the applicable requirements of Article 542.04(d).

When multi-cells are used, a 40 mm (1 1/2 inch) minimum space shall be left between adjacent sections. After the precast cells are in place and backfill has been placed to midheight of the precast concrete box sections on each side, the space between the cells shall be filled with Class SI Concrete. The Class SI Concrete shall be according to Section 1020, except the maximum size coarse aggregate shall be 10 mm (3/8 inch).

#### 540.07 Method of Measurement.

- (a) Contract Quantities. The requirements for the use of Contract Quantities shall conform to Article 202.07(a).
- (b) Measured Quantities. Concrete for cast-in-place box culverts will be measured for payment in cubic meters (cubic yards) as specified in Article 503.21.

Reinforcement bars for cast-in-place concrete box culverts will be measured for payment in kilograms (pounds) as specified in Article 508.07.



When precast concrete box culverts are specified on the plans, they will be measured for payment in meters (feet). The overall length shall be measured as shown on the plans along the centerline of each cell of the culvert. The end sections will be measured for payment in place as each. Cast-in-place collars, headwalls, cutoff walls, wingwalls, footings and Class SI Concrete cast-in-place between adjacent cells will not be measured for payment.

**540.08** Basis of Payment. Cast-in-place concrete box culverts will be paid for at the contract unit price per cubic meter (cubic yard) for CONCRETE BOX CULVERTS. Reinforcement will be paid for according to Section 508.

Expansion bolts will be paid for at the contract unit price each for EXPANSION BOLTS of the size indicated.

When specified on the plans, precast concrete box culverts will be paid for at the contract unit price per meter (foot) for PRECAST CONCRETE BOX CULVERTS of the size specified, which price shall be payment in full for the work as specified and as shown on the plans, including all collars, porous granular bedding material, cast-in-place portions between cells, and excavation, except rock and excavation of unstable and unsuitable material removed below bedding grade.

End sections will be paid for at the contract unit price each for BOX CULVERT END SECTIONS of the culvert number specified, which price shall be payment in full for the work as specified and as shown on the plans, including cut-off walls, headwalls, wingwalls, footings and all cast-in-place portions of the barrel not specified above. If the Contractor, with the approval of the Engineer, elects use a different end section from that shown on the plans, no adjustment in the cost of the precast box culverts or end sections will be allowed.

When the plans specify cast-in-place concrete box culvert and the Contractor, at his/her option, constructs the alternate precast concrete box culvert, no adjustment in the cost for the specified cast-in-place culvert will be allowed. Compensation under the contract bid items for Concrete Box Culverts and Reinforcement Bars shall cover the cost for the precast concrete box culvert alternate complete, including all precast sections, cast-in-place portions, porous granular bedding material, and excavation, except excavation of rock and excavation of unstable and unsuitable material moved below bedding grade.

## SECTION 541. CORRUGATED STRUCTURAL PLATE DRAINAGE STRUCTURES

- **541.01 Description.** This work shall consist of furnishing and installing corrugated structural plate pipe culverts, corrugated structural plate pipe arches and corrugated structural plate arches, fabricated and erected in sections.
- **541.02 Materials.** Materials shall meet the requirements of Article 1006.02. All steel channels, angles, bolts, washers, or other hardware shall be galvanized by the hot-dip process after fabrication. The Department reserves the right to specify either galvanized corrugated steel or aluminum alloy for any installation. When a particular material is specified, no other material will be permitted as an alternate.

When metric sizes are specified on the plans, the next larger available manufactured English size pipe may be used at no extra cost to the Department.

**541.03** Plates. Plates shall consist of structural units of galvanized corrugated steel or aluminum alloy furnished in standard sizes to permit structure length increments of 600 mm (2 ft.). The corrugations shall run at right angles to the longitudinal axis of the structure.

The plates at longitudinal and circumferential seams shall be staggered so that not more than 3 plates come together at one point.

The minimum cover over the top of corrugated structural plate drainage structures shall be as shown in Tables I and II for structural plate pipes and pipe

## Corrugated Structural Plate Drainage Structures

Art. 541.03

arches. The minimum cover for arches shall be span/6 but not less than 300 mm (12 inches).

Plates for corrugated structural plate pipe culverts and for corrugated structural plate pipe arches shall be furnished in the thickness shown in Tables I and II for the respective size and cover over the pipe.

Plates for corrugated structural plate arches shall be furnished in the thickness shown on the plans.

	7.9	
	2.82 2.82 2.82	
	2.82 2.82 2.82	
	2.82 3.56 3.56	
	3.56 3.56 3.56	
	3.56 3.56 3.56	
	3.56 3.56 3.56	
-	3.56 4.32 4.32	

	TABLE IA. WALL THICKNESS FOR CORRUGATED STEEL STRUCTURAL PLATE PIPE CULVERTS For MS 18 LOADING														
	Height of Cover to Nearest 0.1 Meter														
Dia. of Pipe in mm	Pipe in thru thru														
1500	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82
1650	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82
1800	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82
1950	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82
2100	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82
2250	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82
2400	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82
2550		2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	3.56	3.56
2700		2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	3.56	3.56
2850		2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	3.56	3.56	3.56
3000		2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	3.56	3.56	3.56	3.56
3150		2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	3.56	3.56	3.56	3.56	3.56
3300		2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	3.56	3.56	3.56	3.56	3.56	3.56
3450		2.82	2.82	2.82	2.82	2.82	2.82	2.82	3.56	3.56	3.56	3.56	3.56	3.56	3.56
3600		2.82	2.82	2.82	2.82	2.82	2.82	3.56	3.56	3.56	3.56	3.56	3.56	3.56	3.56
3750 3900 4050			2.82 2.82 2.82	2.82 2.82 2.82	2.82 2.82 2.82	2.82 3.56 3.56	3.56 3.56 3.56								
4200 4350 4500			2.82 2.82 2.82	2.82 2.82 3.56	3.56 3.56 3.56	3.56 3.56 4.32	3.56 4.32 4.32								

	TABLE IA. continued														
	Height of Cover to Nearest 0.1 Meter														
	8.2 8.5 8.8 9.1 9.4 9.8 10.1 10.4 10.7 11.0 11.3 11.6 11.9 12.2														
1500	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	
1650	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	
1800	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	3.56	3.56	3.56	3.56	
1950 2100 2250	1950 2.82 2.82 2.82 2.82 2.82 2.82 2.82 2.8														
2400	2.82	3.56	3.56	3.56	3.56	3.56	3.56	3.56	3.56	3.56	3.56	3.56	3.56	3.56	
2550	3.56	3.56	3.56	3.56	3.56	3.56	3.56	3.56	3.56	3.56	3.56	3.56	3.56	3.56	
2700	3.56	3.56	3.56	3.56	3.56	3.56	3.56	3.56	3.56	3.56	3.56	3.56	3.56	3.56	
2850	3.56	3.56	3.56	3.56	3.56	3.56	3.56	3.56	3.56	3.56	3.56	3.56	3.56	4.32	
3000	3.56	3.56	3.56	3.56	3.56	3.56	3.56	3.56	3.56	3.56	4.32	4.32	4.32	4.32	
3150	3.56	3.56	3.56	3.56	3.56	3.56	3.56	3.56	4.32	4.32	4.32	4.32	4.32	4.32	
3300	3.56	3.56	3.56	3.56	3.56	3.56	3.56	4.32	4.32	4.32	4.32	4.32	4.32	4.32	
3450	3.56	3.56	3.56	3.56	3.56	4.32	4.32	4.32	4.32	4.32	4.32	4.32	4.32	4.32	
3600	3.56	3.56	3.56	3.56	4.32	4.32	4.32	4.32	4.32	4.32	4.32	4.32	4.32	4.32	
3750	3.56	3.56	3.56	4.32	4.32	4.32	4.32	4.32	4.32	4.32	4.32	4.32	4.32	4.32	
3900	3.56	3.56	4.32	4.32	4.32	4.32	4.32	4.32	4.32	4.32	4.32	4.32	4.32	4.78	
4050	3.56	4.32	4.32	4.32	4.32	4.32	4.32	4.32	4.32	4.32	4.32	4.32	4.78	4.78	
4200	4.32	4.32	4.32	4.32	4.32	4.32	4.32	4.32	4.32	4.32	4.78	4.78	4.78	4.78	
4350	4.32	4.32	4.32	4.32	4.32	4.32	4.32	4.32	4.32	4.78	4.78	4.78	4.78	4.78	
4500	4.32	4.32	4.32	4.32	4.32	4.32	4.32	4.32	4.78	4.78	4.78	4.78	4.78	4.78	

#### Height of Cover to Nearest Foot Dia. of 2.0\* Pipe in thru 1.5\* Inches 1.0\* 14.0 15.0 16.0 17.0 18.0 19.0 20.0 21.0 22.0 23.0 24.0 25.0 26.0 60.0 0.111 0.111 0.111 0.111 0.111 0.111 0.111 0.111 0.111 0.111 0.1110.111 0.111 0.111 0.111 0.111 0.111 0.111 0.111 0.111 0.111 0.111 0.111 0.111 66.0 0.111 0.111 0.111 0.111 0.111 0.111 72.0 0.111 0.111 0.111 0.111 0.111 0.111 0.111 0.111 0.111 0.111 0.111 0.111 0.111 0.111 0.111 78.0 0.111 0.111 0.111 0.111 0.111 0.111 0.111 0.111 0.111 0.111 0.111 0.111 0.111 0.111 0.111 84.0 0.111 0.111 0.111 0.111 0.111 0.111 0.111 0.111 0.111 0.111 0.111 0.111 0.111 0.111 0.111 90.0 0.111 0.111 0.111 0.111 0.111 0.111 0.111 0.111 0.111 0.111 0.111 0.111 0.111 0.111 0.111 96.0 0.111 0.111 0.111 0.111 0.111 0.111 0.111 0.111 0.111 0.111 0.111 0.111 0.111 0.111 0.111 102.0 0.140 0.140 0.111 0.111 0.111 0.111 0.111 0.111 0.111 0.111 0.111 0.111 0.111 0.111 108.0 0.111 0.111 0.111 0.111 0.111 0.111 0.111 0.111 0.111 0.111 0.140 0.140 0.111 0.111 0.140 114.0 0.111 0.111 0.111 0.111 0.111 0.111 0.111 0.111 0.111 0.111 0.140 0.140 0.111 120.0 0.111 0.140 0.140 0.140 0.140 0.111 0.111 0.111 0.111 0.111 0.111 0.111 0.111 0.111 126.0 0.111 0.111 0.111 0.111 0.111 0.111 0.111 0.111 0.140 0.140 0.140 0.140 0.140 0.111 0.140 0.140 0.140 132.0 0.111 0.111 0.111 0.111 0.111 0.111 0.111 0.140 0.140 0.140 0.111 138.0 0.111 0.111 0.140 0.140 0.140 0.140 0.140 0.140 0.111 0.111 0.111 0.111 0.111 0.140 144.0 0.111 0.111 0.111 0.111 0.111 0.111 0.140 0.140 0.140 0.140 0.140 0.140 0.140 0.140 150.0 0.111 0.111 0.111 0.111 0.140 0.140 0.140 0.140 0.140 0.140 0.140 0.140 0.140 156.0 0.111 0.111 0.140 0.140 0.140 0.140 0.140 0.140 0.140 0.140 0.140 0.140 0.111 162.0 0.111 0.111 0.111 0.140 0.140 0.140 0.140 0.140 0.140 0.140 0.140 0.140 0.140 168.0 0.111 0.111 0.140 0.140 0.140 0.140 0.140 0.140 0.140 0.140 0.140 0.140 0.140 174.0 0.140 0.170 0.111 0.111 0.140 0.140 0.140 0.140 0.140 0.140 0.140 0.140 0.140 180.0 0.170 0.111 0.140 0.140 0.140 0.140 0.140 0.140 0.140 0.140 0.140 0.140 0.170

TABLE IA. WALL THICKNESS FOR CORRUGATED STEEL STRUCTURAL PLATE PIPE CULVERTS For H-20 LOADING (ENGLISH)

	TABLE IA. English continued														
	Height of Cover to Nearest Foot														
	27.0     28.0     29.0     30.0     31.0     32.0     33.0     34.0     35.0     36.0     37.0     38.0     39.0     40.0														
60.0	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	
66.0	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	
72.0	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.140	0.140	0.140	0.140	
78.0	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.140	0.140	0.140	0.140	0.140	0.140	0.140	
84.0	0.111	0.111	0.111	0.111	0.111	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	
90.0	0.111	0.111	0.111	0.111	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	
96.0	0.111	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	
102.0	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	
108.0	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	
114.0	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.170	
120.0	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.170	0.170	0.170	0.170	
126.0	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.170	0.170	0.170	0.170	0.170	0.170	
132.0	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.170	0.170	0.170	0.170	0.170	0.170	0.170	
138.0	0.140	0.140	0.140	0.140	0.140	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	
144.0	0.140	0.140	0.140	0.140	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	
150.0	0.140	0.140	0.140	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	
156.0	0.140	0.140	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.188	
162.0	0.140	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.188	0.188	
168.0	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.188	0.188	0.188	0.188	
174.0	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.188	0.188	0.188	0.188	0.188	
180.0	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.188	0.188	0.188	0.188	0.188	0.188	

	TO WE TO LOADING																	
		Height of Cover to Nearest 0.1 Meter																
Dia. of Pipe in mm	0.3*	0.5*	0.6* thru 3.0	3.3	3.6	3.9	4.3	4.6	4.9	5.2	5.5	5.8	6.1	6.4	6.7	7.0	7.3	7.6
1500	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54
1650	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	3.18
1800	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	3.18	3.18	3.18
1950	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	3.18	3.18	3.18	3.18
2100	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	3.18	3.18	3.18	3.18	3.18
2250	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18
2400	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18
2550		2.54	2.54	2.54	2.54	2.54	2.54	2.54	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18
2700		2.54	2.54	2.54	2.54	2.54	2.54	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.81
2850		2.54	2.54	2.54	2.54	2.54	2.54	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.81	3.81	3.81
3000		3.18	2.54	2.54	2.54	2.54	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.81	3.81	3.81	3.81
3150		3.18	2.54	2.54	2.54	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.81	3.81	3.81	3.81
3300		3.18	2.54	2.54	2.54	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.81	3.81	3.81	3.81	3.81
3450		3.18	2.54	2.54	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.81	3.81	3.81	3.81	3.81	3.81
3600		3.18	2.54	2.54	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.81	3.81	3.81	3.81	3.81	4.44
3750 3900 4050			2.54 3.18 3.18	3.18 3.18 3.18	3.18 3.18 3.18	3.18 3.18 3.18	3.18 3.18 3.18	3.18 3.18 3.18	3.18 3.18 3.18	3.18 3.18 3.81	3.18 3.81 3.81	3.18 3.81 3.81	3.81 3.81 3.81	3.81 3.81 3.81	3.81 3.81 4.44	3.81 4.44 4.44	4.44 4.44 4.44	4.44 4.44 4.44

TABLE IB. WALL THICKNESS FOR CORRUGATED ALUMINUM ALLOY STRUCTURAL PLATE PIPE CULVERTS For MS 18 LOADING

461

4200

4350

4500

Required minimum cover

3.18

3.81

3.81

3.18

3.81

3.81

3.18

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4.44

4.44

4.44

5.08

4.44 5.08 5.08

	TABLE IB. continued														
	Height of Cover to Nearest 0.1 Meter														
	7.9         8.2         8.5         8.8         9.1         9.4         9.8         10.1         10.4         10.7         11.0         11.3         11.6         11.9         12.														
1500	2.54	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18
1650	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.81
1800	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.81	3.81	3.81	3.81
1950	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.18	3.81	3.81	3.81	3.81	3.81	3.81	3.81
2100	3.18	3.18	3.18	3.18	3.18	3.18	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81
2250	3.18	3.18	3.18	3.18	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	4.44
2400	3.18	3.18	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	4.44	4.44
2550	3.81	3.81	3.81	3.81	3.81	3.81	3.81	3.81	4.44	4.44	4.44	4.44	4.44	4.44	4.44
2700	3.81	3.81	3.81	3.81	3.81	3.81	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	5.08
2850	3.81	3.81	3.81	3.81	3.81	4.44	4.44	4.44	4.44	4.44	4.44	4.44	5.08	5.08	5.08
3000	3.81	3.81	3.81	3.81	4.44	4.44	4.44	4.44	4.44	4.44	5.08	5.08	5.08	5.08	5.08
3150	3.81	3.81	3.81	4.44	4.44	4.44	4.44	4.44	5.08	5.08	5.08	5.08	5.08	5.72	5.72
3300	3.81	4.44	4.44	4.44	4.44	4.44	4.44	5.08	5.08	5.08	5.08	5.72	5.72	5.72	5.72
3450	4.44	4.44	4.44	4.44	4.44	5.08	5.08	5.08	5.08	5.72	5.72	5.72	5.72	6.35	6.35
3600	4.44	4.44	4.44	4.44	5.08	5.08	5.08	5.08	5.72	5.72	5.72	6.35	6.35	6.35	6.35
3750 3900 4050	4.44 4.44 4.44	4.44 4.44 5.08	4.44 5.08 5.08	5.08 5.08 5.08	5.08 5.08 5.72	5.08 5.72 5.72	5.08 5.72 5.72	5.72 5.72 6.35	5.72 6.35 6.35	5.72 6.35 6.35	6.35 6.35	6.35	6.35	6.35	
4200 4350 4500	5.08 5.08 5.08	5.08 5.08 5.72	5.08 5.72 5.72	5.72 5.72 5.72	5.72 5.72 6.35	5.72 6.35 6.35	6.35 6.35 6.35	6.35 6.35	6.35						

# TABLE IB. WALL THICKNESS FOR CORRUGATED ALUMINUM ALLOY STRUCTURAL PLATE PIPE CULVERTS For H-20 LOADING (ENGLISH)

	Height of Cover to Nearest Foot																	
Dia. of Pipe in Inches	1.0*	1.5*	2.0* thru 10.0	11.0	12.0	13.0	14.0	15.0	16.0	17.0	18.0	19.0	20.0	21.0	22.0	23.0	24.0	25.0
60.0	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
66.0	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.125
72.0	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.125	0.125	0.125
78.0	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.125	0.125	0.125	0.125
84.0	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.125	0.125	0.125	0.125	0.125
90.0	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125
96.0	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125
102.0		0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125
108.0		0.100	0.100	0.100	0.100	0.100	0.100	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.150
114.0		0.100	0.100	0.100	0.100	0.100	0.100	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.150	0.150	0.150
120.0		0.125	0.100	0.100	0.100	0.100	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.150	0.150	0.150	0.150
126.0		0.125	0.100	0.100	0.100	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.150	0.150	0.150	0.150
132.0		0.125	0.100	0.100	0.100	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.150	0.150	0.150	0.150	0.150
138.0		0.125	0.100	0.100	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.150	0.150	0.150	0.150	0.150	0.150
144.0		0.125	0.100	0.100	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.150	0.150	0.150	0.150	0.150	0.175
150.0 156.0 162.0			0.100 0.125 0.125	0.125 0.125 0.125	0.125 0.125 0.125	0.125 0.125 0.125	0.125 0.125 0.125	0.125 0.125 0.125	0.125 0.125 0.125	0.125 0.125 0.150	0.125 0.150 0.150	0.125 0.150 0.150	0.150 0.150 0.150	0.150 0.150 0.150	0.150 0.150 0.175	0.150 0.175 0.175	0.175 0.175 0.175	0.175 0.175 0.175
168.0 174.0 180.0			0.125 0.150 0.150	0.125 0.150 0.150	0.125 0.150 0.150	0.125 0.150 0.150	0.125 0.150 0.150	0.125 0.150 0.150	0.150 0.150 0.150	0.150 0.150 0.150	0.150 0.150 0.150	0.150 0.150 0.150	0.150 0.150 0.175	0.150 0.175 0.175	0.175 0.175 0.175	0.175 0.175 0.175	0.175	0.175 0.200 0.200

Required minimum cover

	TABLE IB. continued (ENGLISH)  Height of Cover to Nearest Foot														
						Height o	f Cover to	o Nearest	Foot						
	26.0	27.0	28.0	29.0	30.0	31.0	32.0	33.0	34.0	35.0	36.0	37.0	38.0	39.0	40.0
60.0	0.100	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125
66.0	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.150
72.0	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.150	0.150	0.150	0.150
78.0	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.150	0.150	0.150	0.150	0.150	0.150	0.150
84.0	0.125	0.125	0.125	0.125	0.125	0.125	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150
90.0	0.125	0.125	0.125	0.125	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.175
96.0	0.125	0.125	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.175	0.175
102.0	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.175	0.175	0.175	0.175	0.175	0.175	0.175
108.0	0.150	0.150	0.150	0.150	0.150	0.150	0.175	0.175	0.175	0.175	0.175	0.175	0.175	0.175	0.200
114.0	0.150	0.150	0.150	0.150	0.150	0.175	0.175	0.175	0.175	0.175	0.175	0.175	0.200	0.200	0.200
120.0	0.150	0.150	0.150	0.150	0.175	0.175	0.175	0.175	0.175	0.175	0.200	0.200	0.200	0.200	0.200
126.0	0.150	0.150	0.150	0.175	0.175	0.175	0.175	0.175	0.200	0.200	0.200	0.200	0.200	0.225	0.225
132.0	0.150	0.175	0.175	0.175	0.175	0.175	0.175	0.200	0.200	0.200	0.200	0.225	0.225	0.225	0.225
138.0	0.175	0.175	0.175	0.175	0.175	0.200	0.200	0.200	0.200	0.225	0.225	0.225	0.225	0.250	0.250
144.0	0.175	0.175	0.175	0.175	0.200	0.200	0.200	0.200	0.225	0.225	0.225	0.250	0.250	0.250	0.250
150.0 156.0 162.0	0.175 0.175 0.175	0.175 0.175 0.200	0.175 0.200 0.200	0.200 0.200 0.200	0.200 0.200 0.225	0.200 0.225 0.225	0.200 0.225 0.225	0.225 0.225 0.250	0.225 0.250 0.250	0.225 0.250 0.250	0.250 0.250	0.250	0.250	0.250	
168.0 174.0 180.0	0.200 0.200 0.200	0.200 0.200 0.225	0.200 0.225 0.225	0.225 0.225 0.225	0.225 0.225 0.250	0.225 0.250 0.250	0.250 0.250 0.250	0.250 0.250	0.250						

TABLE IIA SIZES. LAYOUT DETAILS AND WALL THICKNESSES FOR CORRUGATED STEEL STRUCTURAL PLATE PIPE ARCHES
For MS 18 LOADING

								-		-	-									
					Height of Cover to Nearest 0.1 meter															
Span mm	Rise mm	Area m2	"B" mm	0.3*	0.5*	0.6*	0.8*	0.9	1.2	1.5	1.8	2.1	2.4	2.7	3.0	3.3	3.7	4.0	4.3	4.6
1854 1930 2057	1397 1448 1499	2.0 2.2 2.4	533 521 559	2.77 2.77 2.77	2.77 2.77 2.77		2.77 2.77 2.77		2.77 2.77 2.77											
2134	1549	2.6	544	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77
2210	1600	2.9	528	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77
2337	1651	3.1	569	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77
2413	1702	3.3	551	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77
2489	1753	3.5	531		2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77
2616	1803	3.7	577		2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77
2692	1854	4.0	554		2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77
2845	1905	4.3	605		2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77
2896	1956	4.6	582		2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77
2972	2007	4.8	556		2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77
3124	2057	5.1	607		2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77
3251	2108	5.4	663		2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77
3327	2159	5.7	638		2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77
3480	2210	5.9	696		2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77

<sup>\*</sup> Required minimum cover

<sup>&</sup>quot;B" Is the vertical distance from a horizontal line across the widest part of the arch to inside crests of the corrugations of the lowest portion of the arch.

4			
66			
			TABLE IIA continued
			Height of Cover to Nearest 0.1 Meter

								TABL	E IIA c	ontinue	ed										54
									Н	eight o	f Cove	r to Ne	earest (	).1 Me	ter						541.03
Span mm	Rise mm	Area m2	"B" mm	0.3*	0.5*	0.6*	0.8*	0.9	1.2	1.5	1.8	2.1	2.4	2.7	3.0	3.3	3.7	4.0	4.3	4.6	۵
3531 3607 3759	2261 2311 2362	6.2 6.6 6.9	668 640 699		2.77 2.77	2.77 2.77 2.77	2.77 2.77 2.77	2.77 2.77 2.77													
3810 3861 3912	2413 2464 2540	7.2 7.5 7.9	671 671 610			2.77 2.77 2.77	2.77 2.77 2.77	2.77 2.77 2.77	င္ပ												
4089 4242 4039	2565 2616 2845	8.3 8.6 9.0	668 734 978			2.77 2.77 2.77	<b>2.77 2.77</b> 2.77	<b>2.77 2.77</b> 2.77	<b>2.77 2.77</b> 2.77	orrugated Drainag											
4115 4267 4318	2896 2946 2997	9.5 9.8 10.1	958 1006 986			2.77 2.77 2.77	2.77 2.77 2.77	2.77 2.77 2.77	I O												
4394 4547 4674	3048 3099 3150	10.6 11.0 11.4	963 1011 1062			2.77 2.77 2.77	2.77 2.77 2.77	2.77 3.51 3.51	Structural Plate Structures												
4750 4826	3200 3251	11.8 12.3	1039 1016			2.77 3.51	2.77 3.51	3.51 3.51	l te												
4953 5029	3302 3353	12.7 13.2	1069 1044				3.51 3.51		3.51 3.51	3.51 3.51	3.51 3.51	3.51 3.51	3.51 3.51	3.51 3.51							

Bold type Indicates areas where soil bearing pressure approx. 290 kPa is required.

<sup>\*</sup> Required minimum cover

<sup>&</sup>quot;B" is the vertical distance from a horizontal line across the widest part of the arch to inside crests of the corrugations of the lowest portion of the arch.

# TABLE IIA SIZES. LAYOUT DETAILS AND WALL THICKNESSES FOR CORRUGATED STEEL STRUCTURAL PLATE PIPE ARCHES For H-20 LOADING (ENGLISH)

(LINOLISI)																				
					Height of Cover to Nearest Foot															
Span Inches	Rise Inches	Area Sq.Ft.	"B"	1.0*	1.5*	2.0*	2.5*	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0
73 76 81	55 57 59	22 24 26	21.0 20.5 22.0	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109 0.109 0.109
84 87 92	61 63 65	28 31 33	21.4 20.8 22.4	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109 0.109 0.109
95 98 103	67 69 71	35 38 40	21.7 20.9 22.7	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109 0.109 0.109
106 112 114	73 75 77	43 46 49	21.8 23.8 22.9		0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109 0.109 0.109
117 123 128	79 81 83	52 55 58	21.9 23.9 26.1		0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109 0.109 0.109
131 137	85 87	61 64	25.1 27.4																	0.109 0.109

<sup>\*</sup> Required minimum cover

 $<sup>\</sup>xi_1^{\text{"B"}}$  Is the horizontal distance from a horizontal line across the widest part of the arch to inside crests of the corrugations of the lowest portion of the arch.

								(I	ENGLI	SH)										
										Heigh	t of Co	ver to	Neares	st Foot						
Span Inches	Rise Inches	Area Sq.Ft.	"B" Inches	1.0*	1.5*	2.0*	2.5*	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0
139 142 148	89 91 93	67 71 74	26.3 25.2 27.5		0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109 0.109 0.109
150 152 154	95 97 100	78 81 85	26.4 26.4 24.0			0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109 0.109 0.109
161 167 159	101 103 112	89 93 97	26.3 28.9 38.5			0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	<b>0.109 0.109</b> 0.109
162 168 170	114 116 118	102 105 109	37.7 39.6 38.8			0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109 0.109 0.109
173 179 184	120 122 124	114 118 123	37.9 39.8 41.8			0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109 0.138 0.138
187 190	126 128	127 132	40.9 40.0																	0.138 0.138
195 198	130 132	137 142	42.1 41.1																	0.138 0.138

TABLE IIA continued

Bold type Indicates areas where soil bearing pressure approx. 3.0 tons per Sq. Ft. is required.

<sup>\*</sup> Required minimum cover

<sup>&</sup>quot;B" is the vertical distance from a horizontal line across the widest part of the arch to inside crests of the corrugations of the lowest portion of the arch.

┦뚩 º	ructi		Drainage Structures	Collabated Stractalar Flat
	⊣≝ ª	Drainage Structure	Š	Ī
ruct		Drainag	je St	011
e Struct	le St		Drainag	Collugated

		TABLE IIB	SIZES, LAY	OUT DE	TAILS a	nd WALL	THICKN			RUGATEI OADING	D ALUMI	NUM AL	LOY STF	RUCTUR	AL PLAT	E PIPE A	ARCHES				
										Heigh	nt of Cov	er to Nea	arest 0.1	Meter							]
Span mm	Rise mm	Area m <sup>2</sup>	"B" mm	0.3*	0.5*	0.6*	0.8*	0.9	1.2	1.5	1.8	2.1	2.4	2.7	3.0	3.3	3.7	4.0	4.3	4.6	
1803 1880 1981	1651 1727 1753	2.3 2.5 2.8	808 815 813	2.54 2.54 2.54																	
2083 2210 2311	1803 1829 1880	3.0 3.3 3.4	826 841 861	2.54 3.18 3.18	2.54 2.54 2.54																
2413 2489 2616	1930 1956 2007	3.7 3.9 4.2	856 820 841	3.18	2.54 2.54 2.54	]_															
2692 2819 2946	2057 2083 2134	4.5 4.7 5.0	828 853 879		2.54 2.54 2.54	2.54 2.54 3.18	2.54 3.18 3.18	Prairiage													
3073 3175 3251	2159 2210 2261	5.3 5.6 5.9	912 897 881		3.18 3.18 3.18	2.54 2.54 2.54	2.54 3.18 3.18	3.18 3.18 3.18	3.18 3.18 3.18												
3353 3505 3556	2311 2337 2388	6.1 6.4 6.8	864 953 879		3.18 3.18 3.18	2.54 2.54 2.54	2.54 3.18 3.18	3.18 3.18 3.18	3.18 3.18 3.18	3.18 3.18 3.18	Structures										
3683 3785 3912	2413 2464 2515	7.1 7.4 7.7	914 894 935			2.54 2.54 3.18	2.54 3.18 3.18	3.18 3.18 3.18	3.18 3.18 3.18	3.18 3.18 3.18	3.18 3.18 3.18	] 8									
3988 4140 4267	2540 2591 2616	8.1 8.5 8.7	912 953 1001			3.18 3.18 3.18															
4242 4343 4470	2870 2921 2946	9.5 9.8 10.2	1001 1067 1118			3.18 3.81 3.81															
4547 4674 4750	2997 3048 3099	10.6 11.1 11.4	1097 1151 1128			3.81 3.81 4.44															
4902 4978	3150 3200	11.9 12.3	1184 1161				4.44 4.44	<u>}</u>													
5105 5182	3251 3302	12.7 13.2	1217 1191				5.08 5.08	] : ] :													

Required minimum cover

<sup>&</sup>quot;B" Is the vertical distance from a horizontal line across the widest part of the arch to inside crests of the corrugations of the lowest portion of the arch.

# TABLE IIB SIZES, LAYOUT DETAILS and WALL THICKNESSES for CORRUGATED ALUMINUM ALLOY STRUCTURAL PLATE PIPE ARCHES FOR H-20 LOADING (ENGLISH)

470			TABLE IIB	SIZES, LAY	OUT DE	TAILS ar	nd WALL	THICKN	FOR	or CORR H-20 LC (ENGLIS	ADING	) ALUMI	NUM ALI	_OY STR	UCTURA	AL PLATE	E PIPE A	RCHES				Art. 541
											He	ight of C	over to N	learest F	oot							1.
	Span Inches	Rise Inches	Area Sq.Ft.	"B"	1.0*	1.5*	2.0*	2.5*	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0	.03
	71 74 78	65 68 69	25 27 30	31.8" 32.1" 32.0"	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	
	82 87 91	71 72 74	32 35 37	32.5" 33.1" 33.9"	0.100 0.125 0.125	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	
	95 98 103	76 77 79	40 42 45	33.7" 32.3" 33.1"	0.125	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	Ç
	106 111 116	81 82 84	48 51 54	32.6" 33.6" 34.6"		0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.125	0.100 0.125 0.125	Drainag
	121 125 128	85 87 89	57 60 63	35.9" 35.3" 34.7"		0.125 0.125 0.125	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.125 0.125	0.125 0.125 0.125	0.125 0.125 0.125	nage
	132 138 140	91 92 94	66 69 73	34.0" 37.5" 34.6"		0.125 0.125 0.125	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.100 0.100	0.100 0.125 0.125	0.125 0.125 0.125	0.125 0.125 0.125	0.125 0.125 0.125	Structure
	145 149 154	95 97 99	76 80 83	36.0" 35.2" 36.8"			0.100 0.100 0.125	0.100 0.100 0.125	0.100 0.100 0.125	0.100 0.100 0.125	0.100 0.100 0.125	0.100 0.100 0.125	0.100 0.100 0.125	0.100 0.100 0.125	0.100 0.100 0.125	0.100 0.100 0.125	0.100 0.125 0.125	0.125 0.125 0.125	0.125 0.125 0.125	0.125 0.125 0.125	0.125 0.125 0.125	Š ]
	157 163 168	100 102 103	87 91 94	35.9" 37.5" 39.4"			0.125 0.125 0.125	0.1 25 0.1 25 0.1 25	0.125 0.125 0.125	0.125 0.125 0.125	0.125 0.125 0.125	0.125 0.125 0.125	0.125 0.125 0.125	0.125 0.125 0.125	0.125 0.125 0.125	0.125 0.125 0.125	0.125 0.125 0.125	0.125 0.125 0.125	0.125 0.125 0.125	0.125 0.125 0.125	0.125 0.125 0.125	מופ
	167 171 176	113 115 116	102 106 110	39.4" 42.0" 44.0"			0.125 0.150 0.150	0.1 25 0.150 0.150	0.125 0.150 0.150	0.125 0.150 0.150	0.125 0.150 0.150	0.125 0.150 0.150	0.125 0.150 0.150	0.125 0.150 0.150	0.125 0.150 0.150	0.125 0.150 0.150	0.125 0.150 0.150	0.125 0.150 0.150	0.125 0.150 0.150	0.125 0.150 0.150	0.125 0.150 0.150	
	179 184 187	118 120 122	114 119 123	43.2" 45.3" 44.4"			0.150 0.150 0.175	0.150 0.150 0.175	0.150 0.150 0.175	0.150 0.150 0.175	0.150 0.150 0.175	0.150 0.150 0.175	0.150 0.150 0.175	0.150 0.150 0.175	0.150 0.150 0.175	0.150 0.150 0.175	0.150 0.150 0.175	0.150 0.150 0.175	0.150 0.150 0.175	0.150 0.150 0.175	0.150 0.150 0.175	
	193 196	124 126	128 132	46.6" 45.7"				0.175 0.175	0.175 0.175	0.175 0.175	0.175 0.175	0.175 0.175	0.175 0.175	0.175 0.175	0.175 0.175	0.175 0.175	0.175 0.175	0.175 0.175	0.175 0.175	0.175 0.175	0.175 0.175	
	201 204	128 130	137 142	47.9" 46.9"				0.200 0.200	0.200 0.200	0.200 0.200	0.200 0.200	0.200 0.200	0.200 0.200	0.200 0.200	0.200 0.200	0.200 0.200	0.200 0.200	0.200 0.200	0.200 0.200	0.200 0.200	0.200 0.200	

<sup>\*</sup> Required minimum cover

Is the vertical distance from a horizontal line across the widest part of the arch to inside crests of the corrugations of the lowest portion of the arch.

Art. 541.03

**541.04 Shipping and Storing.** The loading, transporting, unloading, and storing of material shall be conducted so the steel and aluminum will be kept free from injury. Special care shall be taken to prevent disturbing the curvature in the plates. They shall be blocked to prevent injury during shipment and storage.

### CONSTRUCTION REQUIREMENTS

**541.05** Bearing Surfaces for Corrugated Structural Plate Arches. Each side of each arch shall rest in a groove formed into the masonry or shall rest on a galvanized structural steel angle or channel securely anchored to or embedded in the substructure. Where the span of the arch is greater than 4.5 m (15 ft.) or where the skew angle is more than 20 degrees, a steel bearing surface, having a width at least equal to the depth of corrugation, shall be provided for all arches.

Steel bearings may be either galvanized structural steel channels or angles with horizontal leg securely anchored to the substructure. Channels shall be not less than 5 mm (3/16 inch) in thickness. Angles shall be not less than 75 mm (3 inches) by 75 mm (3 inches) by 6 mm (1/4 inch).

Where the steel bearing is not embedded in a groove in the substructure, one vertical leg shall be punched to allow bolting to the bottom row of plates.

- **541.06 Erection and Backfill.** The erection and backfill for corrugated structural plate drainage structures shall conform to the following requirements:
  - (a) Corrugated Structural Plate Pipe Culverts and Corrugated Structural Plate Pipe Arches. When a plate pipe structure is to be erected in a trench, the width of the trench shall be sufficient to permit thorough tamping of the earth backfill against every plate. The pipe shall be bedded on an earth foundation of uniform density shaped to fit the lower plate at the proper grade. Any soil below the foundation grade which has been disturbed by the Contractor's operations shall be removed. If the foundation excavation has been made deeper than necessary, the foundation shall be brought to proper grade by the addition of well-compacted sand or fine gravel.

Where a firm foundation is not encountered at the grade established, due to soft, spongy, or other unsuitable soil, all such unsuitable soil under the plate pipe structure and for a width of at least one diameter on each side of the structure, shall be removed and replaced with well compacted sand or fine gravel.

Where rock, in either ledge or boulder formation is encountered, it shall be removed and replaced with a cushion of well-compacted sand or fine gravel to a depth below the structure of not less than 40 mm/m (1/2 inch per ft.) of height of fill over the top of the structure, with a minimum allowable thickness of 200 mm (8 inches).

All excavated material not needed on the work shall be disposed of by the Contractor as specified in Article 502.11.

When a corrugated structural plate pipe culvert or corrugated structural plate pipe arch has been completely erected in place, moist fine aggregate meeting the gradations specified in Article 1003.04 shall be placed

### Corrugated Structural Plate Drainage Structures

alongside the structure in layers not to exceed 200 mm (8 inches) in depth, loose measurement, and compacted for the full width of the trench, or so that on each side of the structure there shall be a berm of compacted or undisturbed soil at least as wide as the greatest external dimension of the structure. The fine aggregate shall be placed longitudinally along the structure, except at the outer 1 m (3 ft.) at each end of the structure, impervious material shall be used. The elevation of the backfill material on each side of the structure shall be the same. Special care shall be taken to compact the fine aggregate and impervious material under the haunches of the pipe. The backfill material, fine aggregate and impervious material shall be compacted to the satisfaction of the Engineer by mechanical means. This method of placement shall be continued until the top of the structure is covered with at least 300 mm (12 inches) of backfill material.

(b) Corrugated Structural Plate Arches. Excavation for corrugated structural plate arches shall conform to the applicable provisions of Section 502.

When backfilling a structure before headwalls are placed, the first material shall be placed midway between the ends of the arch forming as narrow a ramp as possible until the top of the arch is reached. The ramp shall be built evenly from both sides, and the backfilling material shall be thoroughly compacted as it is placed. After the ramps have been built to the top of the arch, the remainder of the backfill shall be deposited from the top of the arch, both ways from the center to the ends, and as evenly as possible on both sides of the arch.

If the headwalls are built before the structure is backfilled, the filling material shall first be placed adjacent to one headwall until the top of the arch is reached, after which the fill shall be dumped from the top of the arch toward the other headwall, with care being taken to deposit the material evenly on both sides of the arch.

In multiple installations, the procedure above specified shall be followed, but extreme care shall be used to bring the backfill up evenly on each side of each arch so that unequal pressure will be avoided.

In all cases, the filling material shall be thoroughly but not excessively tamped. Puddling the backfill will not be permitted.

After the structure has been covered with 300 mm (12 inches) of backfill, additional embankment shall be constructed as specified under the subheading "Additional Embankment" in Article 542.04. The height of the additional embankment shall be that specified. No additional compensation will be allowed the Contractor for constructing or removing all or part of the additional embankment.

**541.07 Workmanship.** In addition to compliance with the required details of construction, the completed structural plate structure shall show careful, finished workmanship in all particulars. Plates on which the zinc coating has been damaged or broken, or which show defective workmanship, will be rejected. The following defects are specified as constituting poor workmanship and the presence of any or all of them in any individual plate or in any shipment shall be cause for rejection of the plate or shipment:

- 1. Uneven laps.
- 2. Elliptical shaping (unless specified).
- 3. Variation from a straight centerline.
- 4. Ragged edges.
- 5. Loose, or unevenly lined or spaced bolts.
- 6. Bruised, scaled or broken zinc coating.
- 7. Dents or bends in the metal.

**541.08 Method of Measurement.** Corrugated structural plate drainage structures of the types and sizes specified, or of a particular material when specified, will be measured for payment in place in meters (feet). Measurement will be from end to end along the flow line of pipes and along the bearing leg of structural plate arches.

**541.09** Basis of Payment. This work will be paid for at the contract unit price per meter (foot) for CORRUGATED STRUCTURAL PLATE PIPE CULVERTS of the diameter specified, CORRUGATED STRUCTURAL PLATE PIPE ARCHES of the area specified and CORRUGATED STRUCTURAL PLATE ARCHES of the area specified, which prices shall include all plates, hardware, steel bearings and other materials required, except concrete foundations, and the cost of all structure excavation required except for excavation for steel plate arches and excavation of rock and unstable or unsuitable material.

Excavation for corrugated structural plate arches and rock excavation will be measured and paid for as provided in Section 502, Excavation for Structures.

The removal of unstable or unsuitable material or rock below foundation grade and the replacement thereof with the specified material, including additional excavation required to widen the trench, if required, will be paid for according to Article 109.04, unless the contract contains unit prices for the work included.

### **SECTION 542. PIPE CULVERTS**

**542.01 Description.** This work shall consist of furnishing and installing pipe culverts of the required size. The Type of fill heights shall be as follows:

Fill Heights Over Top of Pipe	Туре
1 m (3 ft.)or less	Type 1
Greater than 1 m (3 ft.), not exceeding 3 m (10 ft.)	Type 2
Greater than 3 m (10 ft.), not exceeding 4.5 m (15 ft.)	Type 3
Greater than 4.5 m (15 ft.), not exceeding 6 m (20 ft.)	Type 4
Greater than 6 m (20 ft.), not exceeding 7.5 m (25 ft.)	Type 5
Greater than 7.5 m (25 ft.), not exceeding 9 m (30 ft.)	Type 6
Greater than 9 m (30 ft.), not exceeding 10.5 m (35 ft.)	Type 7
Greater than 10.5 m (35 ft.)	Special

## Pipe Culverts

542.02 Materials. Materials shall meet the requirements of the following Articles of Section 1000 - Materials:

ltem A	rticle/Section
(a) Corrugated Steel Culvert Pipe	1006.01
(b) Corrugated Steel Pipe Arch	1006.01
(c) Precoated Galvanized Corrugated Steel Culvert Pipe	1006.01
(d) Precoated Galvanized Corrugated Steel Pipe Arch	1006.01
(e) Aluminized Steel Type 2 Corrugated Culvert Pipe	1006.01
(f) Aluminized Steel Type 2 Corrugated Pipe Arch	1006.01
(g) Bituminous Coated Corrugated Steel Culvert Pipe	1006.01
(h) Bituminous Coated Corrugated Steel Pipe Arch	
(i) Zinc and Aramid Fiber Composite Coated Corrugated Steel Pip	e 1006.01
(j) Corrugated Aluminum Alloy Pipe	
(k) Corrugated Aluminum Alloy Culvert Pipe Arch	1006.03
(I) Reinforced Concrete Arch Culvert, Storm Drain,	
and Sewer Pipe	1040.07
(m) Reinforced Concrete Culvert, Storm Drain,	
and Sewer Pipe	
(n) Concrete Sewer, Storm Drain, and Culvert Pipe	1040.04
(o) Reinforced Concrete Elliptical Culvert, Storm Drain, and	
Sewer Pipe	
(p) Polyvinyl Chloride (PVC) Pipe	
(q) Corrugated Polyvinyl Chloride (PVC) Pipe with a Smooth Interior	
(r) Polyvinyl Chloride (PVC) Profile Wall Pipe-794	
(s) Polyethylene (PE) Pipe with a Smooth Interior	1040.16
(t) Polyethylene (PE) Profile Wall Pipe	
(u) Polyvinyl Chloride (PVC) Profile Wall Pipe-304	
(v) Corrugated Polyethylene (PE) Pipe with a Smooth Interior	1040.22
(w) Extra Strength Clay Pipe	1040.02
(x) Clay Sewer Pipe Pipe	
(y) Preformed Flexible Gaskets for Sewer and Culvert Pipe	
(z) Mastic Joint Sealer for Pipe	
(aa) External Sealing Bank	1057

**542.03 Material Permitted.** The following materials will be permitted as alternates for pipe culverts of the class and type specified. Where a particular material is specified, no other kind of material will be permitted as an alternate.

	<u>Class</u>	<u>Material</u>
	Α	Reinforced Concrete (Article 1040.03) Reinforced Concrete Arch Culvert (Article 1040.07) Reinforced Concrete Elliptical Culvert, Storm Drain, & Sewer Pipe (Article 1040.05)
	С	Reinforced Concrete (Article 1040.03) Reinforced Concrete Arch Culvert (Article 1040.07) Reinforced Concrete Elliptical Culvert, Storm Drain & Sewer Pipe (Article 1040.05) Polyvinyl Chloride (PVC) Pipe (Article 1040.10) Corrugated Polyvinyl Chloride (PVC) Pipe with a

Smooth Interior (Article 1040.15)

Polyvinyl Chloride (PVC) Profile Wall Pipe-794 (Article 1040.24)

Polyvinyl Chloride (PVC) Profile Wall Pipe-304 (Article 1040.25)

Polyethylene (PE) Pipe with a Smooth Interior (Article 1040.16)

Polyethylene (PE) Profile Wall Pipe (Article 1040.23)

Aluminized Steel Type 2 Corrugated Culvert Pipe

(Article 1006.01(i))

Aluminized Steel Type 2 Corrugated Pipe Arch (Article 1006.01(i))

Precoated Galvanized Corrugated Steel Culvert Pipe

(Article 1006.01(c))

Precoated Galvanized Corrugated Steel Pipe Arch

(Article 1006.01(c))

Corrugated Aluminum Alloy Pipe (Article 1006.03)

Corrugated Aluminum Alloy Pipe Arch (Article 1006.03)

D Reinforced Concrete (Article 1040.03)

Reinforced Concrete Arch Culvert (Article 1040.07)

Reinforced Concrete Elliptical Culvert, Storm Drain &

Sewer Pipe (Article 1040.05)

Polyvinyl Chloride (PVC) Pipe (Article 1040.10)

Corrugated Polyvinyl Chloride (PVC) Pipe with a

Smooth Interior (Article 1040.15)

Polyvinyl Chloride (PVC) Profile Wall Pipe-794 (Article 1040.24)

Polyvinyl Chloride (PVC) Profile Wall Pipe-304 (Article 1040.25)

Polyethylene (PE) Pipe with a Smooth Interior (Article 1040.16)

Polyethylene (PE) Profile Wall Pipe (Article 1040.23)

Aluminized Steel Type 2 Corrugated Culvert Pipe

(Article 1006.01(i))

Aluminized Steel Type 2 Corrugated Pipe Arch (Article 1006.01(i))

Precoated Galvanized Corrugated Steel Culvert Pipe

(Article 1006.01(c))

Precoated Galvanized Corrugated Steel Pipe Arch

(Article 1006.01(c))

Corrugated Aluminum Alloy Pipe (Article 1006.03)

Corrugated Aluminum Alloy Pipe Arch (Article 1006.03)

Corrugated Polyethylene (PE) Pipe with a

Smooth Interior (Article 1040.23)

Corrugated Steel Culvert Pipe (Article 1006.01(a))

Corrugated Steel Pipe Arch (Article 1006.01(a))

Bituminous Coated Corrugated Steel Culvert Pipe

(Article 1006.01(b))
Bituminous Coated Corrugated Steel Pipe Arch (Article 1006.01(b))

Zinc and Aramid Fiber Composite Coated Corrugated

Steel Pipe (Article 1006.01(h))

When metric sizes are specified on the plans, the next larger available manufactured English pipe may be substituted at no extra cost to the Department.

Where no end treatment is specified, a standard corrugated PE coupling shall be provided at each exposed end with the end of the coupling flush with the end treatment on all PE pipe culverts.

The Contractor may, without additional compensation, substitute a stronger pipe

of the same kind of material specified.

For pipe culverts, only a circular pipe will be permitted when pipe culvert is specified to a diameter and only reinforced concrete elliptical, reinforced concrete arch, aluminum alloy arch, or steel arch will be permitted when pipe culvert is specified as round size equivalent.

Steel or aluminum alloy arch and concrete elliptical or arch pipes will be designated pipe culverts, special for fill heights exceeding 4.5 m (15 ft.).

Extra Strength Clay Pipe and Concrete Sewer Storm Drain, and Culvert Pipe, Class 3, will be permitted for Pipe Culverts Types 2 and 3 only, for all pipe classes.

The kind of material and thickness or thickness class required for the various types of pipe culverts shall be according to Table IA, IB, IC, IIB, and IIIA-C.

	TABL			ONCRETE PIPE FOI GHTS OVER THE		E DIAMETERS	
Nominal	Type 1 Fill Height: 1 m and less 0.3 m min.	Type 2 Fill Height: Greater than	Type 3 Fill Height: Greater than 3.0 m	Type 4 Fill Height: Greater than 5 m	Type 5 Fill Height: Greater than 6.0 m	Type 6 Fill Height: Greater than 7.5 m	Type 7 Fill Height: Greater than 9.0 m
Diameter mm	fill ht. over pipe	Not exceeding 3.0 m	Not exceeding 4.5 m	Not exceeding 6 m	Not exceeding 7.5 m	Not exceeding 9 m	Not exceeding 10.5 m
300	IV	II	III	IV	V	V	V
375 450	IV IV	II II	III III	IV IV	V IV	V	V V
525 600 750 825	IV IV IV	===	≡≡≡	IV IV IV IV	IV IV IV	V V V	V V V
900 1050 1200	     	    	     	IV IV IV	IV IV IV	V V V	V V V
1350 1500 1650	 	II II II	     	IV IV IV	IV V V	V V V	V V V
1800 1950 2100	 		     	IV IV IV	*V *V	*V *V	*V *V
2250 2400 2550 2700	     		≡≡≡	*IV *IV *IV *IV	*V *V *V *V	*V *V *V *V	*V *V *V *V

<sup>\*</sup> Special Design Required

Art. 542.03

# (ENGLISH) TABLE IA: CLASSES OF REINFORCED CONCRETE PIPE FOR THE RESPECTIVE DIAMETERS OF PIPE AND FILL HEIGHTS OVER THE TOP OF PIPE

	Type 1	Type 2	Type 3	Type 4	Type 5	Type 6	Type 7
Nominal Diameter Inches	Fill Height: 3' and less 1'-0" min. fill ht. over pipe	Fill Height:  Greater than 3'  Not exceeding 10'	Fill Height:  Greater than 10'  Not exceeding 15'	Fill Height:  Greater than 15'  Not exceeding 20'	Fill Height: Greater than 20' Not exceeding 25'	Fill Height: Greater than 25' Not exceeding 30'	Fill Height:  Greater than 30'  Not exceeding 35'
12	IV	II	III	IV	V	V	V
15 18	IV IV	 	III III	IV IV	V IV	V	V
21 24 30	IV IV IV	    	     	IV IV IV	IV IV IV	V V V	V V V
36 42 48	     	    	     	IV IV IV	IV IV IV	V V V	V V V
54 60 66	II I I	    	     	IV IV IV	IV V V	V V V	V V V
72 78 84			     	IV IV IV	*V *V	*V *V *V	*V *V *V
90 96 102 108	     		     	* V * V * V * V	*V *V *V *V	*V *V *V *V	*V *V *V *V

Special Design Required

		OF PIPE			OVER THE							GATIONS		
	Тур	e 1	Тур	e 2	Тур	e 3	Тур	e 4	Тур	e 5	Тур	e 6	Тур	e 7
	Fill He 1 m an		Fill H	•	Fill H	_	Fill H	_	Fill H	Ū	Fill H	Ū	Fill H	Ü
Nominal Diameter mm	0.3 m fil over	I	Greate 1 Not exc 3	m	Greate 3 Not exc 4.5	m ceeding	Not exc	m	Not exc	m	Greate 7.5 Not exc 9.0	i m	Greate 9.0 Not exc 10.5	)m
	68mm x 13mm	75mm x 25mm	68mm x 13mm	75mm x 25mm	68mm x 13mm	75mm x 25mm	68mm x 13mm	75mm x 25mm	68mm x 13mm	75mm x 25mm	68mm x 13mm	75mm x 25mm	68mm x 13mm	75mm x 25mm
**250 300	1.63 1.63		1.63 1.63		1.63 1.63		1.63 1.63		1.63 1.63		1.63 1.63		1.63 1.63	
400 450 500	1.63 1.63 1.63		1.63 1.63 1.63		1.63 1.63 1.63		1.63 1.63 1.63		1.63 1.63 1.63		1.63 1.63 1.63		1.63 1.63 1.63	
600 700 800	2.01 2.01 2.01	0.04	2.01 2.01 2.01	0.04	2.01 2.01 2.01	0.04	2.01 2.01 2.01	0.04	2.01 2.01 2.77	3.51	2.01 2.77 3.51	4.27	2.77 3.51 4.27 4.27	0.77
900 1000 1200 1400	2.01 2.77 2.77 2.77	2.01 2.01 2.77 2.77	2.01 2.01 2.01 2.77	2.01 2.01 2.01 2.01	2.01 2.01 2.77 2.77	2.01 2.01 2.01 2.01	2.01 2.77 2.77 2.77	2.01 2.01 2.77 2.77	2.77 2.77 3.51 4.27	2.01 2.01 2.77 2.77	3.51 4.27 2.77E 3.51E	2.77 2.77 2.77 2.77	2.77E 3.51E 3.51E	2.77 2.77 2.77 3.51E
1600 1800	3.51 Z3.51	2.77 2.77	3.51 3.51	2.01 2.01	3.51 3.51	2.77 2.77	3.51 4.27	2.77 2.77	4.27E NB	2.77 2.77	4.27E NB	3.51E 3.51E	NB NB	3.51E 3.51E
2000 2200	Z4.27 Z4.27	2.77 2.77	4.27 4.27	2.01 2.77	4.27 4.27	2.77 2.77	NB NB	2.77 2.77	NB NB	3.51 3.51E	NB NB	3.51E 3.51E	NB NB	3.51E 3.51E
2400 2700	NB NB	2.77 Z2.77	NB NB	2.77 2.77	NB NB	2.77 3.51	NB NB	3.51 3.51	NB NB	3.51E 4.27E	NB NB	3.51E 4.27E	NB NB	4.27E NB
3000 3300 3600		Z3.51 Z4.27 Z4.27		2.77 3.51 3.51		3.51 4.27 NB		4.27 NB NB		NB NB NB		NB NB NB		NB NB NB

TABLE IR: THICKNESS OF CORRUGATED STEEL PIPE FOR THE RESPECTIVE DIAMETER

Note:

<sup>38</sup> mm x 6.5 mm corrugations shall be used in lieu of 68 mm x 13 mm for 250 mm diameters
E Elongate in according to Article 542.04
Use uncoated corrugated steel structural plate pipe according to Section 541
Z 450 mm minimum fill

Art. 542.03

(ENGLISH) TABLE IB: THICKNESS OF CORRUGATED STEEL PIPE FOR THE RESPECTIVE DIAMETER OF PIPE AND FILL HEIGHTS OVER THE TOP OF PIPE FOR 2 2/3" x 1/2" AND 3" x 1" CORRUGATIONS

	Туре	1	Туре	2	Туре	3	Type	4	Туре	5	Type	6	Туре	7
	Fill Heig 3' and le		Fill Heiç		Fill Heio		Fill Hei		Fill Heio		Fill Heig Greater t		Fill Heig	-
Nominal Diameter Inches	1'-0" m fill over pi		3' Not excee		10' Not excee		15' Not exce 20'		20' Not excee		25' Not excee		30' Not excee	
	2 2/3"x1/2"	3"x1"	2 2/3"x1/2"	3"x1"	2 2/3"x1/2"	3"x1"	2 2/3"x1/2"	3"x1"	2 2/3"x1/2"	3"x1"	2 2/3"x1/2"	3"x1"	2 2/3"x1/2"	3"x1"
**10	0.064		0.064		0.064		0.064		0.064		0.064		0.064	
12 15 18	0.064 0.064 0.064		0.064 0.064 0.064		0.064 0.064 0.064		0.064 0.064 0.064		0.064 0.064 0.064		0.064 0.064 0.064		0.064 0.064 0.064	
21 24 30	0.064 0.079 0.079		0.064 0.079 0.079		0.064 0.079 0.079		0.064 0.079 0.079		0.064 0.079 0.079		0.064 0.079 0.109		0.064 0.109 0.138	
36 42 48	0.079 0.109 0.109	0.079 0.079 0.109	0.079 0.079 0.079	0.079 0.079 0.079	0.079 0.079 0.109	0.079 0.079 0.079	0.079 0.109 0.109	0.079 0.079 0.109	0.109 0.109 0.138	0.079 0.079 0.109	0.138 0.168 0.109E	0.109 0.109 0.109	0.168 0.109E 0.138E	0.109 0.109 0.109
54 60 66	0.109 0.138 0.138	0.109 0.109 0.109	0.109 0.109 0.138	0.079 0.079 0.079	0.109 0.109 0.138	0.079 0.109 0.109	0.109 0.138 0.138	0.109 0.109 0.109	0.168 0.138E 0.168E	0.109 0.109 0.109	0.138E 0.168E 0.168E	0.109 0.138 0.138E	0.138E 0.168E NB	0.138 0.138 0.138
72 78 84	Z0.138 Z0.168 Z0.168	0.109 0.109 0.109	0.138 0.168 0.168	0.079 0.079 0.109	0.138 0.168 0.168	0.109 0.109 0.109	0.168 NB NB	0.109 0.109 0.109	NB NB NB	0.109 0.138 0.138E	NB NB NB	0.138E 0.138E 0.138E	NB NB NB	0.138 0.138 0.138
90 96 102 108	NB NB NB NB	0.109 0.109 Z0.109 Z0.109	NB NB NB NB	0.109 0.109 0.109 0.109	NB NB NB NB	0.109 0.109 0.109 0.138	NB NB NB NB	0.109 0.138 0.138 0.138	NB NB NB NB	0.138E 0.138E 0.138E 0.168E	NB NB NB NB	0.138E 0.138E 0.168E 0.168E	NB NB NB NB	0.138 0.168 0.168 NB
114 120 126		Z0.138 Z0.138 Z0.138		0.109 0.109 0.138		0.138 0.138 0.168		0.168 0.168 0.168		0.168E NB NB		NB NB NB		NB NB NB
132 138 144		Z0.168 Z0.168 Z0.168		0.138 0.138 0.138		0.168 0.168 NB		NB NB NB		NB NB NB		NB NB NB		NB NB NB

<sup>125</sup> mm x 25 mm Metric Corrugations may be used in lieu of 3"x1" Corrugations
1 1/2" x 1/4" corrugations shall be used in lieu of 2 2/3" x 1/2" f or 6", 8" and 10" diameters
Elongate in accordance with Article 542.04
NB Use uncoated corrugated steel structural plate pipe in accordance with Section 541

Z 1'-6" minimum fill

												_		
	Туре	1	Тур	e 2	Тур	e 3	Тур	e 4	Тур	e 5	Тур	e 6	Тур	e 7
Nominal Diameter mm	Fill Hei 1 m and 0.3 m r fill over p	l less min.	Greate 1 Not exc	m	Fill He Greate 3 Not exc 4.5	er than m ceeding	4.5 Not exc	er than 5 m	Greate 6.0	m ceeding	Greate 7.5 Not exc	eight: er than 5 m ceeding ) m	Fill H Greate 9.0 Not exc 10.	er than ) m ceeding
	68mm x 13mm	75mm x 25mm	68mm x 13mm	75mm x 25mm	68mm x 13mm	75mm x 25mm	68mm x 13mm	75mm x 25mm	68mm x 13mm	75mm x 25mm	68mm x 13mm	75mm x 25mm	68mm x 13mm	75mm x 25mm
250 300	1.52 1.52		1.52 1.52		1.52 1.52		1.52 1.52		1.52 1.52		1.52 1.52		1.52 1.52	
400 450 500	1.52 1.52 1.52		1.52 1.52 1.52		1.52 1.52 1.52		1.52 1.52 1.52		1.52 1.52 1.52		1.52 1.52 2.67		1.52 2.67 3.43	
600 700 800 900	1.91 2.67 2.67 2.67	2.67 2.67	1.91 1.91 2.67 2.67	1.91 1.91	1.91 2.67 2.67 2.67	1.91 1.91	1.91 2.67 2.67 2.67	2.67 2.67	2.67 2.67 4.17 4.17	2.67 2.67	2.67 3.43 3.43E 3.43E	3.43 3.43	4.17 2.67E 3.43E 3.43E	X
1000 1200 1400	3.43 3.43 4.17	2.67 2.67 2.67	2.67 2.67 3.43	1.91 1.91 1.91	2.67 3.43 4.17	1.91 2.67 2.67	3.43 4.17 X	2.67 2.67 2.67	3.43E 4.17E X	2.67 2.67 3.43	4.17E X X	3.43 X X	4.17E X X	X X X
1600 1800	X X	2.67 3.43	4.17 X	2.67 2.67	X X	2.67 2.67	X X	2.67 3.43	X X	X X	X X	X X	X X	X X
2000 2200	X X	3.43 4.17	X X	2.67 2.67	X X	3.43 3.43	X X	3.43 4.17	X	X	X	X X	X X	X X
2400 2700	X	X	X	3.43 4.17	X	4.17 X	X	X	X	X	X	X	X	X
3000	Х	Х	Х	Х	Х	Х	Х	Х	Х	Х	Х	Х	Х	Х

Note:

E Elongate according to Article 542.04 X Use either steel or concrete pipe Z 450 mm minimum fill

(ENGLISH) TABLE IC: THICKNESS OF CORRUGATED ALUMINUM ALLOY PIPE FOR RESPECTIVE DIAMETER OF PIPE AND FILL HEIGHTS OVER THE TOP OF PIPE FOR 2 2/3" x 1/2" AND 3" x 1" CORRUGATIONS

		Type 1	1	Туре	2	Туре	3	Туре	4	Туре	5	Туре	6	Туре	7
	Nominal Diameter Inches	Fill Heig 3' and le 1'-0" mi fill over pip	ess n.	Fill Hei Greater 3' Not exce 10'	than	Fill Hei Greater 10' Not exce 15'	than	Fill Hei Greater 15' Not exce 20'	than	Fill Heig Greater 20' Not excee 25'	than	Fill Heig Greater 25' Not excee 30'	than	Fill Heig Greater 30' Not excee 35'	than
		2 2/3"x1/2"	3"x1"	2 2/3"x1/2"	3"x1"	2 2/3"x1/2"	3"x1"	2 2/3 "x1/2"	3"x1"	2 2/3"x1/2"	3"x1"	2 2/3"x1/2"	3"x1"	2 2/3"x1/2"	3"x1"
_	10 12	0.060 0.060		0.060 0.060		0.060 0.060		0.060 0.060		0.060 0.060		0.060 0.060		0.060 0.060	
	15 18 21	0.060 0.060 0.060		0.060 0.060 0.060		0.060 0.060 0.060		0.060 0.060 0.060		0.060 0.060 0.060		0.060 0.060 0.105		0.060 0.105 0.135	
	24 30 36	0.075 0.105 0.105	0.105 0.105	0.075 0.075 0.105	0.075 0.075	0.075 0.105 0.105	0.075 0.075	0.075 0.105 0.105	0.105 0.105	0.105 0.105 0.164	0.105 0.105	0.105 0.135E 0.135E	0.105 0.135	0.164 0.105E 0.135E	X X
	42 48 54	0.135 0.135 0.164	0.105 0.105 0.105	0.105 0.105 0.135	0.075 0.075 0.075	0.105 0.135 0.164	0.075 0.105 0.105	0.135 0.164 X	0.105 0.105 0.105	0.135E 0.164E X	0.105 0.105 0.135	0.164E X X	0.135 X X	0.164E X X	X X X
	60 66 72	Z0.164 X X	0.105 0.105 0.135	0.135 0.164 X	0.105 0.105 0.105	X X X	0.105 0.105 0.105	X X X	0.105 0.105 0.135	X X X	X X X	X X X	X X X	X X X	X X X
	78 84 90	X X X	0.135 0.164 0.164	X X X	0.105 0.105 0.135	X X X	0.135 0.135 0.164	X X X	0.135 0.164 X	X X X	X X X	X X X	X X X	X X X	X X X
	96 102 108	X X X	X X X	X X X	0.135 0.164 0.164	X X X	0.164 X X	X X X	X X X	X X X	X X X	X X X	X X X	X X X	X X X
	114 120	X X	X X	X X	0.164 X	X X	X X	X X	X X	X X	X X	X X	X X	X X	X X

## Note:

E Elongate according to Article 542.04
X Use either steel or concrete pipe
Z 1'-6" minimum fill

Equivalent	Corrugated	Corrugated	Corrugated			Type 1			Туре	e 2		Туре	3
Round Size mm	Steel Pipe Arch (68 mm x 13 mm)	Steel Pipe Arch (75 mm x 25 mm)	Aluminum Pipe Arch (68 mm x 13 mm)	Min. Fill Height		Fill Heig Not Excee 1.0 m			Fill He Greate 1.0 Not Exc	r than m		Fill Hei Greater 3 m lot Exce	than n
						Steel	Aluminum Span Rise		Steel ise Span	Aluminum Rise Stee & Alu			Aluminum 75 x 25 mm
400 450 500 600	460 340 510 380 560 420 680 500		460 340 510 380 560 420 680 500	0.3 m 0.3 m 0.3 m 0.5 m	1.63 1.63 1.63 2.01		1.52 1.52 1.52 1.91	1.63 1.63 1.63 2.01		1.52 1.52 1.52 1.91	1.63 1.63 1.63 2.01		1.52 1.52 1.52 1.91
700 800 900	800 580 910 660 1030 740	1016 787	800 580 910 660 1030 740	0.5 m 0.5 m 0.5 m	2.01 2.01 2.01	2.01	2.67 2.67 2.67	2.01 2.01 2.01	2.01	2.67 2.67 2.67	2.01 2.01 2.01	2.01	2.67 2.67 2.67
1000 1200 1400 1600 1800	1150 820 1390 970 1630 1120 1880 1260 2130 1400	1168 914 1330 1030 1550 1200 1780 1360 2010 1500	1150 820 1390 970 1630 1120 1880 1260 2130 1400	0.5 m 0.5 m 0.5 m 0.5 m 0.5 m	2.77 2.77 2.77 4.27 4.27	2.01 2.01 2.01 2.77 2.77	3.43 4.17 4.17 X X	2.01 2.77 2.77 4.27 4.27	2.01 2.01 2.01 2.01 2.77	2.67 3.43 3.43 X X	2.77 2.77 2.77 4.27 4.27	2.01 2.01 2.01 2.77 2.77	3.43 4.17 4.17 X X
2000 2200		2230 1700 2500 1830		0.5 m 0.5 m		2.77 2.77			2.77 2.77			2.77 2.77	
2400 2700		2800 1950 3300 2080		0.5 m 0.5 m		3.51 3.51			2.77 3.51			3.51 4.27	

NOTES: The Type 1 and 3 corrugated steel or aluminum pipe arches shall be placed on soil having a minimum bearing capacity of 290 kN/m<sup>2</sup>

The Type 2 corrugated steel or aluminum pipe arches shall be placed on soil having a minimum bearing capacity of 192 kN/m<sup>2</sup>

This minimum bearing capacity will be determined by the Engineer in the field.

<u>A</u>

2 2/3 x 1/2

inches

NOTES: The Type 1 and 3 corrugated steel or aluminum pipe arches shall be placed on soil having a minimum bearing capacity of 3 tons per square foot. The Type 2 corrugated steel or aluminum pipe arches shall be placed on soil having a minimum bearing capacity of 2 tons per square foot. This minimum bearing capacity will be determined by the Engineer in the field.

The 125 mm x 25 mm Metric Corrugations for Corrugated Steel Pipe Arch may be used in lieu of the 3" x 1" Corrugations.

X Use either steel or concrete.

			SSES OF REIN PECTIVE EQUI\								
						Type 1 Equiva	lent	Typ Reinforced	e 2	Type Reinforced	
Round Size	Concre Elliptio Pipe mm	cal	Cond Ar Pij m	ch pe	Min. Fill Height	Fill Hei Not Exceedii		Fill Hei Greater tha Not Exceed	n 1.0 m	Fill Hei Greater th Not Exceedi	an 3 m
mm	Span	Rise	Span	Rise	RCCP HE & A	HE	Arch	HE	Arch	HE	Arch
375	584	356	457	279	0.4 m	HE-IV	A-IV	HE-I	A-II	HE-III	A-III
450	584	356	559	343	0.4 m	HE-IV	A-IV	HE-I	A-II	HE-III	A-III
525	762	483	660	394	0.3 m	HE-IV	A-IV	HE-I	A-II	HE-III	A-III
600	762	483	724	457	0.3 m	HE-IV	A-IV	HE-I	A-II	HE-III	A-III
686	864	559	921	572	0.3 m	HE-III	A-III	HE-I	A-II	HE-III	A-III
750	965	610	921	572	0.3 m	HE-III	A-III	HE-I	A-II	HE-III	A-III
900	1143	737	1111	676	0.3 m	HE-III	A-III	HE-I	A-II	HE-III	A-III
1050	1346	864	1299	795	0.3 m	HE-II	A-II	HE-I	A-II	HE-III	A-III
1200	1524	965	1486	914	0.3 m	HE-II	A-II	HE-I	A-II	HE-III	A-III
1350	1727	1092	1651	1016	0.3 m	HE-I	A-II	HE-I	A-II	HE-III	A-III
1500	1930	1219	1854	1143	0.3 m	HE-I	A-II	HE-I	A-II	HE-III	A-III
1676	2108	1346	2235	1372	0.3 m	HE-I	A-II	HE-I	A-II	HE-III	A-III
1800	2311	1473	2235	1372	0.3 m	HE-I	A-II	HE-I	A-II	HE-III	A-III

(ENGLISH)
TABLE - IIB: CLASSES OF REINFORCED CONCRETE ELLIPTICAL AND REINFORCED CONCRETE ARCH PIPE FOR THE RESPECTIVE EQUIVALENT ROUND SIZE OF PIPE AND FILL HEIGHTS OVER THE TOP OF PIPE

						Typ Ed	e 1 Juivalent	Ty Reinforce	rpe 2 ed		ype 3 inforced	
Round Size	Concre Elliptic Pipe Inche	al	Ar Pi	crete ch pe hes	Min. Fill Height	Fill H Not Exce	leight eeding 3'	Greate	Height er than 3' eeding 10'	Greate	Height er than 10' ceeding 15'	
					RCCP Inche	\$	Span	Rise	Span	Rise	HE & A	HE
15 18 21 24	23 23 30 30	14 14 19 19	18 22 26 28 1/2	11 13 1/2 15 1/2 18	1'-3" 1'-3" 1'-0" 1'-0"	HE-IV HE-IV HE-IV HE-IV	A-IV A-IV A-IV	HE-I HE-I HE-I HE-I	A-II A-II A-II A-II	HE-III HE-III HE-III HE-III	A-III A-III A-III	Pipe Cul
27 30 36	34 38 45	22 24 29	36 1/4 36 1/4 43 3/4	22 1/2 22 1/2 26 5/8	1'-0" 1'-0" 1'-0"	HE-III HE-III HE-III	A-III A-III A-III	HE-I HE-I HE-I	A-II A-II A-II	HE-III HE-III HE-III	A-III A-III A-III	Culverts
42 48 54	53 60 68	34 38 43	51 1/8 58 1/2 65	31 5/16 36 40	1'-0" 1'-0" 1'-0"	HE-II HE-II HE-I	A-II A-II A-II	HE-I HE-I HE-I	A-II A-II A-II	HE-III HE-III HE-III	A-III A-III A-III	
60 66 72	76 83 91	48 53 58	73 88 88	45 54 54	1'-0" 1'-0" 1'-0"	HE-I HE-I HE-I	A-II A-II A-II	HE-I HE-I HE-I	A-II A-II A-II	HE-III HE-III HE-III	A-III A-III A-III	

### PIPE CULVERTS TABLE - IIIA: PLASTIC PIPE PERMITTED FOR THE RESPECTIVE DIAMETERS OF PIPE AND FILL HEIGHTS OVER THE TOP OF THE PIPE

Nominal	Ту	pe 1 Fill Heig	ht: 1 m and le	ss than 0.3 m	n min. Cover			Туре	2 Fill Height:	Greater than	1 m, not Exc	eeding 3.0 m		
Diameter (mm)	PVC	CPVC	PVCPW -794	PVCPW -304	PE	CPE	PEPW	PVC	CPVC	PVCPW -794	PVCPW -304	PE	CPE	PEPW
250	X	NA	NA	NA	X	NA	NA	X	*	NA	NA	X	NA	NA
300	X	X	X	X	X	X	NA	X	X	X	X	X	X	NA
375	X	X	X	X	NA	X	NA	X	X	X	X	NA	X	NA
450	X	X	X	X	X	X	X	X	X	X	X	X	X	X
525	X	X	X	X	NA	NA	X	X	X	X	X	NA	NA	X
600	X	X	X	X	X	X	X	X	X	X	X	X	X	X
750	X	X	X	X	X	X	X	X	X	X	X	X	X	X
900	X	X	X	X	X	X	X	X	X	X	X	X	X	X

PIPE CULVERTS
TABLE - IIIB: PLASTIC PIPE PERMITTED FOR THE RESPECTIVE DIAMETERS OF PIPE
AND FILL HEIGHTS OVER THE TOP OF THE PIPE

Nominal	Ту	pe 3 Fill Heig	ht: Greater tha	an 3.0 m and	not Exceedin	ıg4.5 m	Туре	4 Fill Height:	Greater than	4.5 m, not Ex	ceeding 6.0 r	n	
Diameter (mm)	PVC	CPVC	PVCPW -794	PVCPW -304	PE	PEPW	PVC	CPVC	PVCPW -794	PVCPW -304			
250 300	X X	* X	NA X	NA X	X X	NA NA	X X	* X	NA X	NA X			
375 450 525	X X X	X X X	X X X	X X X	NA X NA	NA X X	X X X	X X X	X X X	X X X			
600 750 900	X X X	X X X	X X X	X X X	X X X	X X X	X X X	X X X	X X X	X X X			

Indicates this diameter pipe may be used.

NA Not acceptable PVC Polyvinyl Chloride (PVC) Pipe

CPVC

Corrugated Polyvinyl Chloride (PVC) Pipe With a Smooth Interior Polyvinyl Chloride (PVC) Profile Wall Pipe-794 Polyvinyl Chloride (PVC) Profile Wall Pipe-304 Polyvinyl Chloride (PVC) Profile Wall Pipe-304 Polytehylene (PE) Pipe With a Smooth Interior Corrugated Polyethylene (PE) Pipe with a Smooth Interior PVCPW-794 PVCPW-304 PE CPE PEPW

Polythylene (PE) Profile Wall Pipe

May be used with approval of Bureau of Materials and Physical Research and with Manufacturers' Certification.

Χ

Nominal

Diameter (mm) 250

300

375

450

525

600

750

900

Χ

Χ

Χ

Х

Χ

Χ

Art. 542.03

	TABLE - IIIC: PLASTIC PIPE PERMITTED FOR THE RESPECTIVE DIAMETERS OF PIPE AND FILL HEIGHTS OVER THE TOP OF THE PIPE													
	Fill Height: Not Exceed		an 6.0 m		Type 6		ght: Greater ceeding 9.0		m	Type 7		ght: Greate Not Exceedi		
PVC	CPVC	PVCPW -794	PVCPW -304		PVC	CPVC	PVCPW -794	PVCPW -304		PVC				
X	* X	NA X	NA X		X X	* X	NA X	NA X		X X				

Χ

Χ

Χ

Χ

Χ

Х

PIPE CUI VERTS

Χ Indicates this diameter pipe may be used.

ÑΑ Not acceptable

Polyvinyl Chloride (PVC) Pipe PVC

Χ

Х

Χ

Х

Corrugated Polyvinyl Chloride (PVC) Pipe With a Smooth Interior Polyvinyl Chloride (PVC) Profile Wall Pipe-794 CPVC

Χ

Χ

Х

Χ

PVCPW-794 Polyvinyl Chloride (PVC) Profile Wall Pipe-304
Polyvinyl Chloride (PVC) Profile Wall Pipe-304
Polyethylene (PE) Pipe With a Smooth Interior
Corrugated Polyethylene (PE) Pipe With a Smoother Interior
Polythylene (PE) Profile Wall Pipe PVCPW-304 PE

Χ

Χ

Х

CPE

PEPW

May be used with approval of Bureau of Materials and Physical Research and with Manufacturers' Certification.

Χ

Χ

Χ

Χ

Χ

Х

### PIPE CULVERTS (ENGLISH) TABLE - IIIA: PLASTIC PIPE PERMITTED FOR THE RESPECTIVE DIAMETERS OF PIPE AND FILL HEIGHTS OVER THE TOP OF THE PIPE

	Nominal Type 1 Fill Height: 3 ft. and less with 1 ft. min. Cover  Diameter PVC CPVC PVCPW PVCPW PE CPE PEPW PY (inches) -794 -304									2 Fill Heigl	nt: Greater t	han 3 ft., no	ot Exceedin	g 10 ft.	
		PVC	CPVC	-	-	PE	CPE	PEPW	PVC	CPVC	PVCPW -794	PVCPW -304	PE	CPE	PEPW
	10 12	X	NA X	NA X	NA X	X X	NA X	NA NA	X X	* X	NA X	NA X	X X	NA X	NA NA
	15 18 21	XX	X X	X X	X X X	NA X NA	X X NA	NA X X	X X	X	X X	X	NA X NA	X X NA	NA X X
	24 30 36	X X	X X X	X X X	X X X	X X X	X X X	X X X	X X X	X X X	X X	X X	X X X	X X X	X X X

PIPE CULVERTS (ENGLISH)
TABLE - IIIB: PLASTIC PIPE PERMITTED FOR THE RESPECTIVE DIAMETERS OF PIPE
AND FILL HEIGHTS OVER THE TOP OF THE PIPE

	Nominal	Ту	pe 3 Fill He	eight: Greate	er than 10 ft.	and not E	xceeding 15	ift.	Туре	4 Fill Heig	ht: Greater t	than 15 ft. n	ot Exceedir	ng 20 ft.	
	Diameter (inches)	PVC	CPVC	PVCPW -794	PVCPW -304	PE	PEPW		PVC	CPVC	PVCPW -794	PVCPW -304			
	10 12	X	* X	NA X	NA X	X	NA NA		X	* X	NA X	NA X			
	15 18 21	X X X	X X X	X X X	X X X	NA X NA	NA X X		X X X	X X X	X X X	X X X			
	24 30 36	X X X	X X X	X X X	X X X	X X X	X X X		X X X	X X X	X X X	X X X			

Indicates this diameter pipe may be used.

Not acceptable NA

Χ

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Polyvinyl Chloride (PVC) Pipe PVC

Corrugated Polyvinyl Chloride (PVC) Pipe With a Smooth Interior Polyvinyl Chloride (PVC) Profile Wall Pipe-794 CPVC

PVCPW-794 PVCPW-304 PΕ

Polyvinyl Chloride (PVC) Profile Wall Pipe-304 Polyethylene (PE) Pipe With a Smooth Interior

Corrugated Polyethylene (PE) Pipe With a Smooth Interior CPE

Polythylene (PE) Profile Wall Pipe PEPW

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			TABLE	E - IIIC: PL		<b>E PERMITT</b>		NGLISH) HE RESPEC E TOP OF T		IETERS OF	PIPE		
Nominal		Fill Height: Not Exceed	Greater Tha	an 20 ft.		Type 6		ght: Greater ceeding 30			Type 7	ght: Greate Not Exceedi	
Diameter (inches)	Diameter (inches) PVC CPVC PVCPW PVCPW PVCPW PVCPW -794 -304 PVC CPVC PVCPW PVCPW -304										PVC		
10 12	X X	* X	NA X	NA X		X	* X	NA X	NA X		X		
15 18 21	X X X	X X X	X X X	X X X		X X X					X X X		
24 30 36	X X X	Х	Х	Х		X X X					X X X		

Х Indicates this diameter pipe may be used.

ÑΑ Not acceptable

PVC

Polyvinyl Chloride (PVC) Pipe
Corrugated Polyvinyl Chloride (PVC) Profile Wall Pipe-794 CPVC

PVCPW-794 Polyvinyl Chloride (PVC) Profile Wall Pipe-304
Polyvinyl Chloride (PVC) Profile Wall Pipe-304
Polyethylene (PE) Pipe With a Smooth Interior
Corrugated Polyethylene (PE) Pipe With a Smooth Interior
Polythylene (PE) Profile Wall Pipe PVCPW-304 PE

CPE

PEPW

May be used with approval of Bureau of Materials and Physical Research and with Manufacturers' Certification.

### CONSTRUCTION REQUIREMENTS

**542.04 Method I Construction.** Unless otherwise permitted in writing by the Engineer because of conditions encountered in construction, all pipe culverts, except entrance culverts, shall be constructed according to the following requirements:

(a) Removal and Replacement of Unstable or Unsuitable Material or Rock. Where unstable material such as soft or spongy soil, unsuitable material or rock in either ledge or boulder formation is encountered at locations along the line of the pipe culvert and at the grade established for the culvert, the material or rock shall be removed and replaced before proceeding with the construction.

The unstable and unsuitable material shall be removed to a depth determined by the Engineer and for a width of one diameter (or equivalent diameter) of the pipe on each side of the pipe culvert, and replaced with granular material meeting the approval of the Engineer. Rock shall be removed to an elevation 300 mm (12 inches) lower than the bottom of the pipe or to a depth equal to 40 mm/m (1/2 inch per ft.) of ultimate fill height over the top of the pipe culvert, whichever is the greater depth, and for a width as specified in (b) below, and replaced with moist fine aggregate meeting the approval of the Engineer. Replacement material shall be placed in 200-mm (8-inch) layers, loose measurement, and compacted to the satisfaction of the Engineer by mechanical means.

(b) Trenching. Pipe culverts shall be constructed in trenches, excavated either in embankments and/or natural ground.

When practical to do so, the Contractor shall excavate a diversion channel for the water. The channel cut and shape and its backfilling with granular material shall meet the approval of the Engineer. This work will not be paid for as a separate item, but shall be considered as included in the contract unit price bid for the item of pipe culvert involved and no additional compensation will be allowed.

When all or a portion of a pipe will be in fill, the embankment, or a portion thereof, shall be constructed prior to excavating the trench. The embankment shall be constructed to a height which will provide approximately 300 mm (12 inches) of cover over the pipes, except that in no case, even when pipes with a vertical height greater than 1.2 m (4 ft.) are to be installed, shall the height of the embankment constructed exceed 1.5 m (5 ft.) or result in a finished trench depth exceeding 1.5 m (5 ft.). The width of the top of the embankment shall not be less than 4 m (13 ft.) on each side of the pipe culvert, measured at right angles to its centerline, and the longitudinal slopes shall not be steeper than 1:6 (V:H). The embankment shall be constructed according to the requirements of Section 205, except the material shall be select material from excavation or borrow, meeting the approval of the Engineer.

Trenches shall be excavated to an elevation 100 mm (4 inches) below that of the bottom of the pipe and to a specified width on each side of the pipe (according to inside diameters or equivalent pipe diameters) of not more than: 225 mm (9 inches) for pipe sizes up to 600 mm (24 inches), 300 mm

### Pipe Culverts

(12 inches) for pipe sizes greater than 600 mm (24 inches) and up to 1.2 m (48 inches), and 450 mm (18 inches) for pipe sizes greater than 1.2 m (48 inches). Care should be exercised to maintain vertical faces while excavating the trench. If the width of the trench at the top of the trench exceeds the maximum horizontal dimension of the pipe by more than the above specified widths as a result of careless or faulty construction methods, that portion of the trench shall be corrected by the Contractor at his/her own expense by backfilling in 200 mm (8 inch) layers and again excavating the trench to the required width. The backfill material and its placement shall be the same as stipulated for the embankment.

(c) Preparation of Foundation. When the trench has been excavated for the entire length of the pipe culvert and any required removal and replacement of unstable or unsuitable material or rock has been completed, as specified in Article 542.04(a), the foundation for the pipe culvert shall be prepared.

Well compacted moist fine aggregate, at least 100 mm (4 inches) in depth below the pipe culvert, shall be placed the entire width of the trench and for the length of the pipe culvert, except that well compacted impervious material shall be used for the outer 1 m (3 ft.) at each end of the pipe. When the trench has been widened by the removal and replacement of unstable or unsuitable material, the foundation material shall be placed for a width not less than the above specified widths on each side of the pipe. The fine aggregate and impervious material shall meet the approval of the Engineer and shall be compacted to the Engineer's satisfaction by mechanical means.

When pipe having bells or hubs is used, cross trenches not more than 50 mm (2 inches) wider than the bell or hub, shall be excavated to provide uniform bearing along the length of the pipe.

(d) Laying Pipe. No pipe culvert shall be placed until the trench and the prepared foundation have been approved by the Engineer.

The pipe shall be laid so that the flow line of the finished culvert will be at the grade shown on the plans or established by the Engineer. Laying of pipes for the pipe culvert shall commence at the outlet end, with the spigot ends of the pipe pointing in the direction of the flow, and proceed toward the inlet end with pipes abutting, and true to line and grade.

The ends of the pipe shall be carefully cleaned before the pipes are placed and the pipes shall be placed to avoid unnecessary handling on the foundation. As each length of the pipe is laid, the ends of the pipe shall be protected to prevent the entrance of any material. The pipes shall be fitted and matched so that when laid in the work, they will form a culvert with a smooth, uniform invert.

When corrugated steel or aluminum alloy culvert pipe (including bituminous coated steel or aluminum and precoated steel) is used, the longitudinal lap shall be placed at the sides and separate sections of pipe shall be joined with tightly drawn, approved connectors.

Circular corrugated steel or aluminum alloy culvert pipe (including

bituminous coated steel or aluminum and precoated steel) that are specified as elongated in Table I shall be elongated vertically 5 percent out of a round before any fill is placed. A tolerance in elongation of  $\pm$  0.75 percent will be permitted. The pipe, except for bituminous coated corrugated steel or aluminum culvert pipe, shall be elongated by one of the following methods:

- (1) Deformation during fabrication.
- (2) Elongation by the use of wires, rods or straps during fabrication.
- (3) Elongation at the time of installation by the use of vertical struts, wedged or jacked inside the pipe in a manner approved by the Engineer.

Bituminous coated corrugated steel or aluminum circular culvert pipe shall be elongated by either method (1) or (2) prior to coating.

Pipe elongated by the manufacturer shall be marked to show the top. Pipe elongated by deformation during fabrication shall be stored, transported and handled in such a manner so that at the time of installation the pipe shall have retained its elongation.

When the pipe is elongated by method (2) or (3), it shall be installed in a manner that will permit the gradual reduction of elongation as the fill over the pipe is placed. This reduction in elongation shall be as directed by the Engineer and may be accomplished by the use of softwood compression caps when struts or jacks are used, or by the use of turnbuckles or other devices when wires, rods or straps are used.

After the fill has been placed and compacted, all struts, wires, rods or straps shall be removed, and any holes in the pipe resulting from their use shall be plugged in a manner satisfactory to the Engineer. Heavy asphaltic or tar material, or other material, or a device meeting the approval of the Engineer may be used to plug the holes.

No strutting or elongation will be permitted on corrugated steel or aluminum (including bituminous coated steel or aluminum and precoated steel) pipe arches.

All joints in concrete culverts shall be sealed with preformed flexible gasket or mastic joint sealer conforming to Sections 1056 or 1055 or external sealing bands conforming to Section 1057. When mastic joint sealer is used, the material shall completely fill the joint after the pipes have been brought together. Each section of pipe shall be pushed or pulled as tight as reasonably possible to the section in place to ensure tight joints. Pipe having a diameter or equivalent diameter greater than 1 m (42 inches) shall be set or "brought home" with a winch, come-a-long or other positive means.

All handling holes in concrete culverts shall be filled with a precast plug, sealed and covered with mastic or mortar.

(e) Backfilling. As soon as the condition of the pipe culvert will permit, the entire width of the trench shall be backfilled with moist fine aggregate

### Pipe Culverts

meeting the gradations specified in Article 1003.04 to a height of at least the elevation of the center of the pipe. The fine aggregate shall be placed longitudinally along the pipe culvert, except at the outer 1 m (3 ft.) at each end of the culvert which shall be backfilled with impervious material. The elevation of the backfill material on each side of the pipe shall be the same. The space under the pipe shall be completely filled. The backfill material, fine aggregate and impervious material shall be placed in 200 mm (8 inch) layers, loose measurement. When using PVC, PE, or corrugated metal pipe, the pipe shall be backfilled with a moist fine aggregate 300 mm (1 ft.) over the top of the pipe and compacted to a minimum of 85% of standard lab density by mechanical means. When reinforced concrete pipes are used, the backfill shall be compacted to a minimum of 85% of standard lab density when the trench is within 600 mm (2 ft.) of the pavement structure. The materials used for backfilling shall meet the approval of the Engineer.

When using PVC, PE, or corrugated metal pipe a minimum of 300 mm (1 ft.) of cover from the top of the pipe to the top of the subgrade will be required.

The installed pipe and its embedment shall not be disturbed when using movable trench boxes and shields.

The remainder of the trench shall be backfilled with select material, from excavation or borrow, free from large or frozen lumps, clods or rock, meeting the approval of the Engineer. The material shall be placed in layers not exceeding 200 mm (8 inches) in depth, loose measurement and compacted to 95 percent of the standard laboratory density. Compaction shall be obtained by use of mechanical tampers or with approved vibratory compactors. Before compacting, each layer shall be wetted or dried to bring the moisture content within the limits of 80 to 110 percent of optimum moisture content determined according to AASHTO T 99 (Method C). The backfill material on each side of the pipe culvert shall be kept at approximately the same elevation. If the Contractor, at his/her option, uses fine aggregate instead of select material, it shall be compacted by mechanical means to the satisfaction of the Engineer, and no additional compensation will be allowed.

When the trench has been widened for the removal and replacement of unstable or unsuitable material, the backfilling with moist fine aggregate and impervious material, to at least the elevation of the center of the pipe, will be required for a width of at least the specified widths on each side of the pipe. The remaining width of each layer may be backfilled with select material. Each 200 mm (8 inch) layer for the entire trench width shall be completed before beginning the placement of the next layer.

Embankment. After backfilling to the top of the trench for the entire length or portion of the length constructed by this method, and when the top of the trench is not 300 mm (12 inches) over the top of the pipe, the embankment shall be constructed to an elevation of one foot above the top of the pipe. While constructing the embankment, no heavy earth-moving equipment will be permitted within 1.5 m (4 ft.) of either side of the pipe culvert. The Contractor shall not introduce any loads upon the pipe culvert, other than equipment permitted by the Engineer for the construction of the

embankment to the required height, until the Contractor has constructed additional embankment as specified.

The embankment shall be constructed according to Section 205, except the material shall be select material, from excavation or borrow, meeting the approval of the Engineer. The select material to within 1.5 m (4 ft.) of each side of the pipe culvert shall be compacted by mechanical means. The embankment shall be constructed to the width and longitudinal slopes specified in Article 542.04 (b).

- (g) Additional Embankment. After the trench has been backfilled and embankment constructed to an elevation of 300 mm (12 inches) over the top of the pipe culvert, additional embankment shall be constructed before the Contractor will be permitted to introduce any loads upon the pipe culvert. The required cover, including any embankment cover over the pipe and additional embankment, shall be sufficient for the maximum load, including the weight of equipment, which the Contractor proposes to operate or move across the pipe culvert. The total cover required for various loadings will be as shown in Table III.
- (h) Deflection Testing for Pipe Culverts. All PE and PVC pipe culverts will be tested for deflection not less than 30 days after the pipe is installed and the backfill compacted.

For PVC and PE pipe culverts with diameters 600 mm (24 inches) or smaller, a mandrel drag shall be used for deflection testing. For PVC and PE pipe culverts with diameters over 600 mm (24 inches), deflection measurements other than by a mandrel drag shall be used.

Where the mandrel is used, the mandrel shall be furnished by the Contractor and pulled by hand through the pipeline with a suitable rope or cable connected to each end. Winching or other means of forcing the deflection gauge through the pipeline will not be allowed.

The mandrel shall be of a shape similar to that of a true circle enabling the gauge to pass through a satisfactory pipeline with little or no resistance. The mandrel shall be of a design to prevent it from tipping from side to side and to prevent debris build-up from occurring between the channels of the adjacent fins or legs during operation. Each end of the core of the mandrel shall have fasteners to which the pulling cables can be attached. The mandrel shall have 9 various sized fins or legs of appropriate dimension for various diameter pipes. Each fin or leg shall have a permanent marking that states its designated pipe size and percent of deflection allowable.

The outside diameter of the mandrel shall be 95% of the base inside diameter, where the base inside diameter is:

For all PVC pipe and Profile Wall PE pipe: as defined using ASTM D 3034 methodology.

For all other PE pipe: the average inside diameter based on the minimum and maximum tolerances specified in the corresponding ASTM or AASHTO material specifications.

# Pipe Culverts

If the pipe is found to have a deflection greater than that specified, that pipe section shall be removed, replaced, and retested.

TABLE III

						Wheel Loa	d (kilonev	vtons)				
		9	44	89	133	178	223	267	311	356	400	445
	Nominal or Equivalent Diameter (mm)					Total	Cover (m	eters)				
Type 1 & 4	200 to 2700, incl.	0.3	0.6	0.9	1.2	1.5	1.7	2.0	2.3	2.6	2.9	3.2
Type 2 & 3	200 to 2700, incl.	0.6	0.9	1.2	1.7	2.1	2.6	3.0	3.5	4.0	4.3	4.6
Type 5 & 6	200 to 1800, incl.	0.3	0.6	0.8	0.9	1.1	1.2	1.4	1.5	1.5	1.7	1.8
	1950 to 2700, incl.	0.3	0.5	0.6	0.9	1.1	1.2	1.4	1.5	1.5	1.7	1.8
Туре 7	200 to 1800, incl.	0.3	0.5	0.6	0.8	0.9	0.9	1.1	1.1	1.2	1.2	1.4
	1950 to 2700, incl.	0.3	0.3	0.6	0.6	0.9	0.9	1.1	1.1	1.2	1.2	1.4

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# (ENGLISH) TABLE III

	Wheel Load (tons)											
		1	5	10	15	20	25	30	35	40	45	50
	Nominal or Equivalent Diameter (inches) Total Cover (feet)											
Type 1 & 4	8" to 108", incl.	1.0	2.0	3.0	4.0	5.0	5.5	6.5	7.5	8.5	9.5	10.5
Type 2 & 3	8" to 108", incl.	2.0	3.0	4.0	5.5	7.0	8.5	10.0	11.5	13.0	14.0	15.0
Type 5 & 6	8" to 72", incl.	1.0	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.0	5.5	6.0
	78" to 108", incl.	1.0	1.5	2.0	3.0	3.5	4.0	4.5	5.0	5.0	5.5	6.0
Type 7	8" to 72", incl.	1.0	1.5	2.0	2.5	3.0	3.0	3.5	3.5	4.0	4.0	4.5
	78" to 108", incl.	1.0	1.0	2.0	2.0	3.0	3.0	3.5	3.5	4.0	4.0	4.5

The height of additional embankment constructed over Pipe Culverts, Special, shall be as specified.

Additional embankment shall be constructed according to Section 205. Its width on each side of the pipe culvert shall be 4 m (13 ft.) and the longitudinal slopes shall not be steeper than 1:6 (V:H). The width of the additional embankment, measured along the pipe culvert, shall be the actual fill width indicated on the cross sections at the elevation required in the above table or sufficient to accommodate two-way traffic of the Contractor's grading operations and so that no equipment is operated within 3 m (10 ft.) of either shoulder line, whichever is the least.

Where the elevation of the additional embankment is above the elevation of the finished embankment grade, the Contractor will be required to remove it at the time of his/her finish grading operations.

When the elevation of the finished embankment grade is higher than that of the additional embankment, the Contractor shall scarify the surface of the slopes and the top of the embankment to ensure a thorough bonding of the embankment material.

**542.05 Method II Construction.** Method II Construction may be used to construct pipe culverts, except entrance culverts, only when specified or when physical conditions are encountered in construction which make the use of Method I Construction impractical and written permission is obtained from the Engineer. In Method II Construction, all or a portion of a pipe culvert may be constructed in a trench excavated in the existing ground prior to placement of the required embankment.

The construction procedures for Method II Construction shall be the same as previously specified in Article 542.04 for Method I Construction, except as follows:

- (a) Trenching. Trenching shall be as specified in Article 542.04(b), except that the depth of the trench shall be such that the bottom elevation of the pipe will not be less than one-tenth of the diameter (or equivalent diameter) of the pipe below the top of the trench. When the elevation of the bottom of the pipe is less than the specified distance below the natural ground line, sufficient embankment shall be constructed to an elevation that will provide pipe embedment to at least one-tenth of the diameter (or equivalent diameter) of the pipe before the trench is excavated.
- (b) Embankment. Embankment extending to an elevation of 300 mm (12 inches) over the top of the pipe shall be constructed according to the requirements of Article 542.04(f), except that the material up to the elevation of the center of the pipe and extending to a width of at least 450 mm (18 inches) on each side of the pipe, exclusive of the outer 1 m (3 ft.) at each end of the pipe, shall consist of moist fine aggregate. At the outer 1 m (3 ft.) at each end of the culvert, impervious material shall be used.
- **542.06 Method III Construction.** Entrance culverts, either private or field, shall be constructed according to the following requirements:
  - (a) Trenching. Normally, trenching other than that necessary to place the pipe culvert to a depth equal to one-tenth of its external diameter will not be required. Additional trenching may be necessary to some cases due to the location of a pipe culvert. The trenching shall be performed as specified for

Method II except as follows:

The trench shall be excavated only to the bottom of the pipe culvert and for a width sufficient to place the pipe. The bottom of the trench shall be shaped to approximately the size and shape of the pipe culvert.

(b) Preparation of Foundation. After the trench has been excavated for the entire length of the pipe culvert, and any necessary removal and replacement of unstable or unsuitable material or rock has been completed, the foundation for the pipe culvert shall be prepared as follows:

The bottom of the trench shall be shaped to substantially fit the exterior of the pipe. If necessary, material meeting the approval of the Engineer shall be used to fill depressions. The material comprising the foundation shall then be compacted to the satisfaction of the Engineer.

- (c) Laying Pipe. No pipe culvert shall be placed in the trench until it and the foundation have been approved by the Engineer. The pipe shall be laid as specified for Method I construction.
- (d) Placing Backfill in the Trench and/or Constructing Embankment. As soon as the condition of the pipe culvert will permit, the trench shall be backfilled and/or embankment constructed.

The material used shall be select material, meeting the approval of the Engineer, from excavation or borrow. The material shall be placed in 200 mm (8 inch) layers, loose measurement, and compacted to the satisfaction of the Engineer. Compaction shall be obtained by mechanical means or, when approved by the Engineer, hand tampers weighing not less than 4 kPa (0.6 psi) of tamping surface may be used. Special care shall be taken to completely fill the space under the pipe. The material shall be placed to an elevation one foot above the top of the pipe culvert or to the finished grade, whichever is the lesser height.

When embankment is being constructed, the material used for its construction shall be placed to a width, on each side of the pipe culvert, not less than one diameter of the pipe.

- (e) Deflection testing for entrance culverts will be at the option of the Engineer. When deflection is required by the Engineer, it shall be according to Article 542.04.
- **542.07 End Treatment.** End treatment of pipe culverts shall consist of a cast-in-place reinforced concrete end section, a precast reinforced concrete flared end section, a metal end section of aluminum or steel, an inlet box for side slope or an inlet box for median slope. When an end treatment is required, it will be specified on the plans. When the type of end treatment to be used is specified on the plans, only that type shall be used.

When the pipe is at a 15° skew or less with the roadway and the diameter is 2100 mm (84 inches) or less, if end treatment is required but the type of treatment is not specified on the plans, the Contractor shall have the option of using either a cast-in-place concrete headwall or a prefabricated end section of precast reinforced concrete or metal. If a prefabricated end section is used, it shall be of the same



material as the pipe culvert, except for polyethylene (PE) pipe which shall be a metal end section.



- (a) Cast-In-Place Reinforced Concrete End Section. Cast-in-place reinforced concrete end sections shall be constructed of Class SI Concrete according to the requirements of Section 503 and the details shown on the plans.
- (b) Precast Reinforced Concrete Flared End Section. Precast reinforced concrete flared end sections shall be constructed according to the details shown on the plans and shall conform to the applicable requirements of AASHTO M 170M (M 170) Class III, Wall B reinforced concrete pipe. End blocks shall be either precast or cast in place, and shall be in proper position and backfilled according to the applicable paragraphs of Article 502.10 prior to the installation of the precast reinforced concrete flared end sections.
  - (1) Grating for Precast Reinforced Concrete Flared End Sections. Grating shall be installed on precast reinforced concrete flared end sections at the location specified on the plans. The grating shall be fabricated and installed according to the details shown on the plans.

Structural steel shapes and plates shall conform to the requirements of Article 1006.04. Galvanized steel pipe shall conform to the requirements of Article 1006.27(b). Bolts, nuts and washers shall conform to the requirements of Article 1006.27(f).

Fabrication of the grating shall be completed and ready for assembly before galvanizing.

(c) Metal End Sections. Metal end sections shall be fabricated of aluminum or steel, and all component parts shall be of the same material. When steel end sections are used, the base metal, rivets and spelter coating shall conform to AASHTO M 36M (M 36). When aluminum end sections are used, the material shall conform to AASHTO M 196M (M 196). Toe plates shall be furnished and the metal thickness shall be the same as that used in the end section.

Fabrication shall be according to the dimensions and details shown on the plans. All 3-piece bodies shall have 2.77 mm (0.109 inch) sides and 3.51 mm (0.138 inch) center panels. Width of center panels shall be greater than 20% of the pipe periphery. Multiple panel bodies shall have lap seams which shall be tightly jointed with M10 (3/8 inch) rivets or bolts.



(d) Inlet Box for Side Slope, Median Slope and Median Ditch Check. Inlet boxes for side slopes, median slopes and median ditch checks shall be constructed of the sizes and locations and according to the standard details shown on the plans. Inlet Box for Side Slope shall be cast in place. Inlet Box for Median Slope and Inlet Box For Median Ditch Check shall be either cast in place or precast units.

If inlet boxes are cast in place, they shall be constructed of Class SI Concrete according to the applicable requirements of Section 503.

### Pipe Culverts

If precast units are used, they shall be fabricated of Class PC Concrete according to the applicable requirements of Section 504.

The minimum bar lap for both precast and cast-in-place units shall be 325 mm (13 inches).

The exposed edges of concrete shall be beveled 20 mm (3/4 inch) on both precast and cast-in-place units.

Galvanized steel pipe required for the construction of inlets shall meet the requirements of ASTM A 53, Grade B, Schedule 40, or approved equal. Galvanized U-bolts, nuts and washers shall meet the requirements of Article 1006.27(f). Steel plates shall meet the requirements of Article 1006.04, and shall be galvanized according to the requirements of AASHTO M 111 after fabrication.

Grating and frames required for Inlet Box for Median Ditch Check shall be steel or cast grating fabricated according to the details shown on the plans and shall be approved by the Engineer. Steel grating and frames shall conform to Article 1006.04 and shall be galvanized according to requirements of AASHTO M 111 after fabrication. Cast grating shall conform to Article 1006.15, Grade 60-40-18, or to Article 1006.14 and proof-load tested according to Federal Specifications RR-F-621. The proof-load shall be 110 kN (25,000 lbs.) on a 225 mm x 225 mm (9 inch x 9 inch) cast block. Cast frames shall conform to Article 1006.14. Cast grating and frames shall not be galvanized.

Pressure lock type steel grating and riveted steel grating with reticuline bars will be accepted for galvanizing according to the requirements of AASHTO M 111.

Steel grating shall seat firmly in the frame but shall not be secured to the frame. The grating shall be cut in such manner that all riveted or welded connections are left in tact. The edges of the main bearing bars shall be laterally supported by transverse bars. Grating shall be approved by the Engineer. All welding shall be done according to the applicable requirements of Section 505, and shall be done before galvanizing.

For flush inlet boxes for medians, steel grating shall have the main bearing bars running parallel to the centerline of the median. The main bearing bars shall be as specified or shall be 89 mm (3 1/2 inches) in depth and have a minimum section modulus of 203200 mm<sup>3</sup>/m (3.78 cubic inches per ft.) width of grating with a maximum spacing of 50 mm (2 inches) center-to-center.

For inlet boxes for median ditch checks, steel grating shall have the main bearing bars running perpendicular to the centerline of the inlet box. The main bearing bars shall have a minimum section modulus of 132600 mm<sup>3</sup>/m (2.47 cubic inches per ft.) width of grating. The cross sectional shape shall be rectangular or a modified "I" but shall not have any flanges which would retain trash. The length and width of the grating shall be such as to leave no more than 16 mm (5/8 inch) clearance on either side when placed in the frame.

Either steel frames and grating or cast frames and grating may be used at the Contractor's option, but steel frames with cast grating or cast frames with steel grating will not be permitted.

Excavation and backfill shall be performed according to the applicable portions of Section 502. When precast units are used, a 75-mm (3-inch) deep bedding of sand conforming to Article 1003.01 for gradation FA-1 or FA-2 shall be provided under the full width and length of the unit. All voids around the pipe entrance, both inside and out, shall be sealed with mortar.



**542.08 Pipe Elbows, Tees, and Collars.** Pipe elbows and tees shall be installed in culvert pipe at the locations specified on the plans. The degree of elbow and the pipe size required for elbows and tees shall be detailed on the plans for each individual installation. Before the delivery of the elbows, the Contractor, with the Engineer, shall field verify the degree of elbow required for each installation.

Elbows, tees, and collars shall be of the same material as the pipe culvert.

(a) Reinforced Concrete. Reinforced concrete elbows and tees shall be fabricated according to the details shown on the plans and the following requirements.

Reinforced concrete pipe for both elbows and tees shall conform to the requirements of AASHTO M 170M (M 170).

Additional reinforcement for elbows shall conform to the requirements of AASHTO M 31M (M 31) or AASHTO M 53M (M 53).

The cement mortar with bonding agent for both elbows and tees shall be approved by the Engineer prior to use..

Reinforced concrete collars shall be constructed according to Section 503 and as detailed on the plans. Reinforcement for concrete collars shall be according to Section 508.

(b) Metal. The bonding or connecting device for the elbows, tees, and/or collars will be approved by the Engineer prior to use.

**542.09 Pipe Culverts (Temporary).** Pipe culverts used as drainage structures for proposed temporary connections and detour roads shall be designated Pipe Culverts (Temporary) and shall be furnished, installed and maintained by the Contractor as specified, except that the material for the pipe culvert need not be new material.

Used pipe culvert with a thickness equal to or greater than that required in Table IB or IC of Article 542.03 may be used provided it meets the approval of the Engineer. The Resident Engineer will visually inspect the pipe for acceptance. Small dents or inadequate galvanizing on the pipe will not be cause for rejection.

After the temporary connection or detour road has been removed, the pipe culvert shall become the property of the Contractor. The salvage value of the pipe shall be reflected in the unit price bid for the item of Pipe Culvert (Temporary) involved.

- **542.10 Method of Measurement.** Pipe culverts of the diameter specified will be measured for payment in place in meters (feet) except that the length measured shall not exceed the length shown on the plans or authorized in writing by the Engineer. When elbows or tees are included in pipe culverts, the measured length of the culvert shall exclude the length of the elbow or tee section.
- **542.11** Basis of Payment. This work will be paid for at the contract unit price per meter (foot) for PIPE CULVERTS, or PIPE CULVERTS (TEMPORARY), of the class and type specified; or PIPE CULVERTS, SPECIAL; of the diameters or equivalent round size specified, and of the particular kind of material when specified.

The removal of unstable or unsuitable material, or rock below plan bedding grade, and the replacement with the specified material, including additional excavation required to widen the trench should such excavation be necessary to accomplish the removal of unstable or unsuitable material, or rock, will be paid for according to Article 109.04 unless the contract contains unit prices for the work included. Excavation in rock will be measured and paid for according to Section 502 for Rock Excavation for Structures.

Select materials for embankment will be measured and paid for as specified in Section 202. Embankment constructed over pipe culverts, as specified in Article 542.04, up to the elevation of the finished embankment grade will be measured and paid for as specified in Section 205. Embankment constructed above the elevation of the finished embankment grade and its subsequent removal will not be paid for as a separate item, but shall be considered as included in the contract unit price bid for the item of Pipe Culvert involved.

When the Contractor has the option of using either cast-in-place reinforced concrete end sections or prefabricated end sections as specified in Article 542.07, the work will be paid for at the contract unit price each for END SECTIONS, for the size of pipe specified.

When specified on the plans, precast reinforced concrete flared end sections will be paid for at the contract unit price each for PRECAST REINFORCED CONCRETE FLARED END SECTIONS, of the diameter or equivalent round size specified, which price shall include furnishing and installing the flared end section complete in place, including the end block, excavating, backfilling and connecting to the pipe.

When specified on the plans, steel end sections and aluminum end sections will be paid for at the contract unit price each for STEEL END SECTIONS and ALUMINUM END SECTIONS, respectively, of the diameter or equivalent round size specified, which price shall include furnishing and installing the end section complete in place, including the toe plate, excavating, backfilling and connecting to the pipe.

End sections for polyethylene (PE) culvert pipe will be paid for at the contract unit price each for METAL END SECTIONS of the diameter specified, which price shall include furnishing and installing the end section complete in place, including the toe plate, excavating, backfilling and connecting to the pipe.

When cast-in-place reinforced concrete end sections are specified on the plans, the work will be paid for at the contract unit price each for CAST-IN-PLACE REINFORCED CONCRETE END SECTIONS of the diameter specified.



Reinforcement will be paid for according to Section 508.

When cast-in-place concrete collars are specified on the plans, the concrete will be paid for at the contract unit price per cubic meter (cubic yard) for CONCRETE COLLAR. Reinforcement will be paid for according to Section 508. Expansion bolts, when required, will be paid for according to Section 540.

When specified on the plans, elbows and tees for polyethene or metal pipe will be paid for at the contract unit price each of PIPE ELBOW and PIPE TEE, of the diameter specified, complete in place.

Grating for precast reinforced concrete flared end sections will be paid for at the contract unit price each for GRATING FOR CONCRETE FLARED END SECTION, of the size specified, which price shall include fabricating, furnishing and installing and installing the grating as specified, including fabricating the necessary mounting holes in the precast reinforced concrete flared end section.

Inlet boxes for median slopes and for side slopes will be paid for at the contract unit price each for INLET BOX, STANDARD 542501; INLET BOX, STANDARD 542521; INLET BOX, STANDARD 542511, INLET BOX, STANDARD 542506; INLET BOX, STANDARD 542536; INLET BOX, STANDARD 542541; complete in place, which price shall include the Class SI Concrete or Class PC Concrete, reinforcement bars, galvanized pipe and hardware, excavating, bedding when required, backfilling and connecting to the pipe when required.

Inlet box for median ditch check will be paid for at the contract unit price each for INLET BOX, STANDARD 542526, or INLET BOX, STANDARD 542531, complete in place, which price shall include the Class SI Concrete or Class PC Concrete, reinforcement bars, frames and grating, excavating, bedding when required, backfilling and connecting to the pipe when required.

Inlet boxes to be placed flush in medians will be paid for at the contract unit price each for FLUSH INLET BOX FOR MEDIAN, STANDARD 542546, complete in place, which price shall include Class SI Concrete or Class PC Concrete, reinforcement bars, frames and grating, excavating, bedding when required, backfilling, and connecting to the pipe when required.

Reinforced concrete pipe elbows will be paid for at the contract unit price each for REINFORCED CONCRETE PIPE ELBOW, of the diameter specified, complete in place.

Reinforced concrete pipe tees will be paid for at the contract unit price each for REINFORCED CONCRETE PIPE TEE, of the pipe diameter and riser diameter specified, complete in place.

#### **SECTION 543. INSERTION LINING OF PIPE CULVERTS**

- **543.01 Description.** This work shall consist of insertion lining of existing pipe culverts with polyethylene (PE) or reinforced plastic mortar (RPM) plastic liner pipes.
- **543.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 Materials:

	Item Article	e/Section
(a)	Polyethylene (PE) Plastic Pipe (Note 1)	1040.16
(b)	Polyethyline (PE) Profile Wall Pipe (Note 1)	1040.18
(c)	Reinforced Plastic Mortar (RPM) Pipe (Note 1)	1040.17
<b>_</b> (d)	Non-Shrink Grout	1024.01



Note 1. Insertion linings are specified to minimum allowable inside diameters. Any of the listed pipe materials are permitted if the inside diameter requirement is met.



Nominal Size mm	PE-F	714 O.D	RPM I.D.	1-D3262 O.D.	Profile Wa	all-F894 O.D.	
0120 11111	1.0	<u> </u>	1.0.	0.5.	1.5.	J.B.	
250					250	284.5	
300	302.8	323.9			300	342.1	
325	317.5	339.9					
350	332.5	355.6					
375					375	428.0	
400	380	406.4					
450	426.7	457.2	457.2	495.3	450	514.1	
500	474.2	508.0	508.0	548.6			
525					525	600.7	
550	521.7	558.8					
600	569.0	609.6	609.6	655.3	600	687.3	
675					675	772.9	
700	664.0	711.2					
750			762.0	812.8	750	859.0	
800	749.3	802.4					
900	853.7	914.4	914.4	922.8	900	1032.5	
1000	936.0	1002.5			1000	1148.1	
1050	995.9	1066.8	1066.8	1130.3	1050	1205.7	
1200	1123.7	1203.5	1219.2	1290.3			
1350			1371.6	1450.3			
1375	1311.4	1404.6					
1500			1524.0	1597.7			
1600	1499.1	1605.5					
1650			1676.4	1757.7			
1800			1828.8	1915.2			
1950			1981.2	2072.6			
2100			2133.6	2235.2			
2250			2286.0	2395.2			
2400			2438.4	2555.2			

Nominal Size in.	PE-F I.D	714 O.D	RPN I.D.	Л-D3262 О.D.	Profile Wa	all-F894 O.D.
10					10	11.2
12	11.92	12.75			12	13.47
13	12.50	13.38				
14	13.09	14				
15					15	16.85
16	14.96	16				
18	16.80	18	18	19.5	18	20.24
20	18.67	20	20	21.6		
21					21	23.65
22	20.54	22				
24	22.40	24	24	25.8	24	27.06
27					27	30.43
28	26.14	28				
30			30	32.0	30	33.82
32	29.5	31.59				
36	33.61	36	36	38.3	36	40.65
40	36.85	39.47			40	45.20
42	39.21	42	42	44.5	42	47.47
48	44.24	47.38	48	50.8		
54			54	57.1		
55	51.63	55.3				
60			60	62.9		
63	59.02	63.21				
66			66	69.2		
72			72	75.4		
78			78	81.6		
84			84	88.0		
90			90	94.3		
96			96	100.6		

## **CONSTRUCTION REQUIREMENTS**

**543.03 General.** Prior to installing the insertion lining, the culvert shall be cleared of debris or other materials so that the inserted pipe will not be resting on or against nor be irregularly supported by such materials.

Plastic Liner Pipe (PE) shall be joined into a continuous length by the butt fusion



method according to ASTM D 2657 or by an approved screw-on or push-on joint. Plastic Liner Pipe (Profile Wall) shall be joined by heat fusion, extrusion, welding, screw-on, or other approved connections. Plastic Liner Pipe (RPM) shall be joined according to the manufacturer's recommendations using joint lubricant. The joining may be accomplished in a jacking pit or other convenient location where the assembled liner can be brought into alignment with the existing culvert bore without damage. The Engineer shall approve each joint before each section of liner pipe is inserted.

The insertion may be made by pushing or pulling the assembled liner pipe from either end of the culvert. The insertion operation shall not cause the joints to separate in any way. The Engineer may require the liner to have a temporary nose cone or plug to guide the liner pipe past minor obstructions. The handling of plastic liner pipe shall be such that the pipe is not damaged. Pipe with deep scratches or gouges shall be removed and replaced by the Contractor at his/her own expense.

After the liner has been completely inserted and has been inspected in place by the Engineer, it shall be cut off flush with the ends of the existing culvert or as otherwise directed by the Engineer and grouted in place. Liner pipe that has been exposed to the sun before the insertion is made shall be allowed to cool to the temperature of the existing culvert before it is cut off and grouted. Only enough water to make a stiff but workable grout shall be used.

The grout shall extend into the annular space between the culvert and liner for a minimum distance of 150 mm (6 inches) to a flexible grout stop comprised of flexible foamed polyethylene, pavement joint backer rod, wadded newspaper or other material approved by and installed to the satisfaction of the Engineer. If the outside diameter of the liner pipe is less than 2/3 that of the inside diameter of the existing culvert, the grout shall extend for the full length of the culvert taking care that the grouting pressures are not so high as to distort the liner pipe. Where only the ends of the pipe are grouted, drainage of the annular space between the culvert and culvert liner shall be provided by drilling a circumferential line of weep holes in the lower half of the liner pipe just upstream from the downstream grout stop. The weep holes shall be not less than 10 mm (3/8 inch) nor more than 15 mm (1/2 inch) in diameter and shall be spaced circumferentially at 75-mm (3-inch) centers starting 20 degrees above the invert and extending upwards to the spring line of the liner.

**543.04 Method of Measurement.** Insertion culvert liners shall be measured for payment in meters (feet) in place.

**543.05 Basis of Payment.** This work will be paid for at the contract unit price per meter (foot) for INSERTION CULVERT LINER of the inside diameter specified, which price shall include all materials, labor, equipment, and excavation, except excavation in rock, necessary to complete the work.

Excavation in rock will be measured and paid for as specified in Section 502 for Rock Excavation for structures.

#### **SEWERS**

#### SECTION 550. STORM SEWERS

**550.01 Description.** This work shall consist of constructing storm sewers of the required inside diameter with the necessary fittings.

**550.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 - Materials:

	Item	Article/Section
(a)	Reinforced Concrete Arch Culvert, Storm Drain and	
	Sewer Pipe (Note 1)	1040.07
(b)	Reinforced Concrete Culvert, Storm Drain and Sewer Pipe	1040.03
(c)	Concrete Sewer, Storm Drain and Culvert Pipe	1040.04
(d)	Reinforced Concrete Elliptical Culvert, Storm Drain	
	and Sewer Pipe (Note 1)	1040.05
(e)	Polyvinyl Chloride (PVC) Pipe	1040.10
(f)	Corrugated Polyvinyl Chloride (PVC) Pipe with a Smooth Into	erior 1040.15
(g)	Polyvinyl Chloride (PVC) Profile Wall Pipe-794	1040.24
(h)	Extra Strength Clay Pipe	1040.02
(i)	Clay Sewer Pipe	1040.02
(j)	Performed Flexible Gaskets for Sewer and Culvert Pipe	1056
(k)	Mastic Joint Sealer for Pipe	1055
(l)	External Sealing Band	1057

Note 1. The class of elliptical and arch pipe used for various storm sewer sizes and heights of fill shall conform to the requirements for circular pipe.

**550.03** Kinds of Material Permitted. The following materials will be permitted as alternates for storm sewers of the type specified. Where a particular material is specified, no other kind of material will be permitted as an alternate.

	Class	<u>Material</u>
     	A	Reinforced Concrete (Article 1040.03) Reinforced Concrete Arch Culvert (Article 1040.07) Reinforced Concrete Elliptical Culvert, Storm Drain, & Sewer Pipe (Article 1040.05)
	В	Reinforced Concrete (Article 1040.03) Reinforced Concrete Arch Culvert (Article 1040.07) Reinforced Concrete Elliptical Culvert, Storm Drain, & Sewer Pipe (Article 1040.05) Polyvinyl Chloride (PVC) Pipe (Article 1040.10) Corrugated Polyvinyl Chloride (Article 1040.10) Pipe with a Smooth Interior (Article 1040.15) Polyvinyl Chloride (PVC) Profile Wall Pipe-794 (Article 1040.24)

When metric sizes are specified on the plans, the next larger available manufactured English pipe may be substituted at no extra cost to the Department.

The Contractor may, without additional compensation, substitute a stronger pipe

of the same kind of material specified.



Extra Strength Clay Pipe, and Concrete Sewer Storm Drain and Culvert Pipe, Class 3, will be permitted for storm sewer, of the types shown in the storm sewer fill height tables, for all pipe classes.

For storm sewer, only a circular pipe will be permitted when storm sewer is specified to be a diameter and only reinforced concrete arch and reinforced concrete elliptical will be permitted when pipe culvert is specified as round size equivalent.

The kind of material and thickness or thickness class required for the various types of storm sewers shall be according to the following tables:

# KIND OF MATERIAL PERMITTED AND STRENGTH REQUIRED FOR THE RESPECTIVE DIAMETERS OF PIPE AND FILL HEIGHTS OVER THE TOP OF THE PIPE FOR STORM SEWERS

		Fill Height						Fill Height								Fill Height		
	Type 1			1 m and	d less		Type	2		Grea	ter than '	1 m	Туре	3		Great	ter than 3	3.0m
			with	0.3 m r	nin. cove	er				Not Ex	ceeding 3	3.0 m			1	Not Ex	ceeding 4	4.5 m
Nom.																		
Dia.	RCCP	CSP				PVCPW	RCCP	CSP				PVCPW	RCCP	CSP				PVCPW
(mm)	Class	Class		PVC	CPVC	-794	Class	Class	ESCP	PVC	CPVC	-794	Class	Class	ESCP	PVC	CPVC	-794
250 300 375	NA IV IV	3	Х	X X X	NA X X	NA X X	NA III III	1 1 2	*X *X X	X X X	X X	NA X X	NA IV IV	3	X	X X X	X X	NA X X
450 525 600	IV IV IV			X X X	X X X	X	     	2 2 2	X X X	X X X	X X X	X X X	IV IV IV			X X X	X X X	X X
675 750 825	IV III III		X	X X X	NA X NA	NA X NA	== == ==		X X X	X X X	NA X NA	NA X NA	IV IV IV			X X X	NA X NA	NA X NA
900 1050 1200	 	NA NA	X NA	X NA NA	X NA NA	X NA NA	     	NA NA	X NA	X NA NA	X NA NA	X NA NA	IV IV IV	NA NA	NA	X NA NA	X NA NA	X NA NA
1350 1500 1650		NA NA NA	NA NA NA	NA NA NA	NA NA NA	NA NA NA	    	NA NA NA	NA NA NA	NA NA NA	NA NA NA	NA NA NA	IV IV III	NA NA NA	NA NA NA	NA NA NA	NA NA NA	NA NA NA
1800 1950 2100		NA NA NA	NA NA NA	NA NA NA	NA NA NA	NA NA NA	=======================================	NA NA NA	NA NA NA	NA NA NA	NA NA NA	NA NA NA	     	NA NA NA	NA NA NA	NA NA NA	NA NA NA	NA NA NA
2250 2400 2550 2700		NA NA NA NA	NA NA NA NA	NA NA NA NA	NA NA NA NA	NA NA NA NA		NA NA NA NA	NA NA NA NA	NA NA NA NA	NA NA NA NA	NA NA NA NA		NA NA NA NA	NA NA NA NA	NA NA NA NA	NA NA NA NA	NA NA NA NA

RCCP CSP ESCP PVC CPVC PVCPW-794 X NA

Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe
Concrete Sewer, Storm Drain, and Culvert Pipe
Extra Strength Clay Pipe
Polyvinyl Chloride (PVC) Pipe
Corrugated Polyvinyl Chloride (PVC) Pipe With A Smooth Interior
Polyvinyl Chloride (PVC) Profile Wall Pipe-794
Indicates this diameter pipe may be used.
Not Acceptable
May also use standard strength Clay Sewer Pipe
May be used if Bureau of Materials and Physical Research approves and with Manufacturers' Certification.

RCCP Class V - 150D, etc. shall be furnished in accordance with AASHTO M 170M Section 6. These loads are D loads to produce a 0.3 mm crack. Note

# Storm Sewers

# English

#### STORM SEWERS



# KIND OF MATERIAL PERMITTED AND STRENGTH REQUIRED FOR THE RESPECTIVE DIAMETERS OF PIPE AND FILL HEIGHTS OVER THE TOP OF THE PIPE FOR STORM SEWERS

				Fill He	•						ill Height					Fill Heigh	
	Type 1		;	3 ft. and	d less		Type	2		Grea	ter than 3	3 ft.	Туре	3	Gı	eater than	10 ft.
			with	1. ft. m	nin. cove	r				Not Ex	ceeding	10 ft.			No	t Exceeding	15 ft.
Nom.																	
Dia.	RCCP	CSP				PVCPW	RCCP	CSP				PVCPW	RCCP	CSP			PVCPW
(inch)	Class	Class		PVC	CPVC		Class	Class	ESCP	PVC	CPVC	-794	Class	Class	ESCP P	VC CPVC	-794
10 12 15	NA IV IV	3	Х	X X X	NA X X	NA X X	NA III III	1 2 2	*X X X	X X X	X X	NA X X	NA IV IV	3	X X X	** X X	NA X X
18 21 24	IV IV IV			X X X	X X X	X	     	2 2 2	X X X	X X X	X X	X X X	IV IV IV		X X X	X X X	X X X
27 30 33	IV III III		X	X X X	NA X NA	NA NA	     		X X	X X X	NA X NA	NA X NA	>>>		X X X	NA X NA	NA X NA
36 42 48	===	NA NA	X NA	X NA NA	X NA NA	X NA NA	     	NA NA	X NA	X NA NA	X NA NA	X NA NA	>>>	NA NA	X N NA N	A NA	X NA NA
54 60 66	=	NA NA NA	NA NA NA	NA NA NA	NA NA NA	NA NA NA	    	NA NA NA	NA NA NA	NA NA NA	NA NA NA	NA NA NA	≥≥≡	NA NA NA	NA N NA N NA N	A NA	NA NA NA
72 78 84		NA NA NA	NA NA NA	NA NA NA	NA NA NA	NA NA NA	    	NA NA NA	NA NA NA	NA NA NA	NA NA NA	NA NA NA	===	NA NA NA	NA N NA N NA N	A NA A NA	NA NA NA
90 96 102 108		NA NA NA NA	NA NA NA NA	NA NA NA NA	NA NA NA NA	22 22 24 24 24 24 24		NA NA NA NA	NA NA NA NA	NA NA NA NA	NA NA NA NA	NA NA NA NA		NA NA NA NA	NA N NA N NA N NA N	A NA A NA A NA	NA NA NA NA

RCCP CSP ESCP PVC CPVC PVCPW-794 Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe Concrete Sewer, Storm Drain, and Culvert Pipe Extra Strength Clay Pipe Polyvinyl Chloride (PVC) Pipe With A Smooth Interior Polyvinyl Chloride (PVC) Pipe With A Smooth Interior Polyvinyl Chloride (PVC) Profile Wall Pipe-794 Indicates this diameter pipe may be used. Not Acceptable

May also use standard strength Clay Sewer Pipe
May be used if Bureau of Materials and Physical Research approves and with Manufacturers' Certification.

Note RCCP Class V - 3160D, etc. shall be furnished in accordance with AASHTO M 170 Section 6. These loads are D loads to produce a 0.01 inch crack.

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# KIND OF MATERIAL PERMITTED AND STRENGTH REQUIRED FOR THE RESPECTIVE DIAMETERS OF PIPE AND FILL HEIGHTS OVER THE TOP OF THE PIPE FOR STORM SEWERS

			Fill Heig	ght			Fill Hei	ight			Fill Heig	ght
	Type 4		Greater than	4.5 m	Type 5		Greater tha	n 6.0 m	Type 6		Greater than	7.5 m
		Not exceeding 6.0 m					Not Exceedi	ng 7.5 m			Not Exceeding	g 9.0 m
Nom.												
Dia.	RCCP			PVCPW	RCCP			PVCPW	RCCP			PVCPW
(mm)	Class	PVC	CPVC	-794	Class	PVC	CPVC	-794	Class	PVC	CPVC	-794
250 300 375	NA V V	X X	X X	NA X X	NA V-150D V-145D	X X	X X	NA X X	NA V-180D V-160D	X X X	** X	NA X
450 525 600	V	X X X	X	X X X	V	X X X	X X X	X X	V-150D V V	X X X		
675 750 825	V V IV	X X Y	NA X NA	NA X NA	V	X X	NA NA	NA NA	V	X X Y	NA NA	NA NA
900 1050 1200	IV IV IV	X NA NA	X NA NA	X NA NA	V V	X NA NA	NA NA	NA NA	v V	X NA NA	NA NA	NA NA
1350 1500 1650	IV IV IV	NA NA NA	NA NA NA	NA NA NA	V V IV	NA NA NA	NA NA NA	NA NA NA	V	NA NA NA	NA NA NA	NA NA NA
1800 1950 2100	IV IV IV	NA NA NA	NA NA NA	NA NA NA	IV IV IV	NA NA NA	NA NA NA	NA NA NA	V	NA NA NA	NA NA NA	NA NA NA
2250 2400 2550 2700		NA NA NA NA	NA NA NA NA	NA NA NA NA	IV IV IV	NA NA NA NA	NA NA NA NA	NA NA NA NA	V	NA NA NA NA	NA NA NA NA	NA NA NA NA

RCCP CSP ESCP PVC CPVC PVCPW-794 Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe
Concrete Sewer, Storm Drain, and Culvert Pipe
Extra Strength Clay Pipe
Polyvinyl Chloride (PVC) Pipe
Corrugated Polyvinyl Chloride (PVC) Pipe With A Smooth Interior
Polyvinyl Chloride (PVC) Profile Wall Pipe-794
Indicates this diameter pipe may be used.
Not Acceptable
May also use standard strength Clay Sewer Pipe
May be used if Bureau of Materials and Physical Research approves and with Manufacturers' Certification. ŅΑ

RCCP Class V - 150D, etc. shall be furnished in accordance with AASHTO M 170M Section 6. These loads are D loads to produce a 0.3 mm crack. Note

## English STORM SEWERS

# KIND OF MATERIAL PERMITTED AND STRENGTH REQUIRED FOR THE RESPECTIVE DIAMETERS OF PIPE AND FILL HEIGHTS OVER THE TOP OF THE PIPE FOR STORM SEWERS

	Fill Height Type 4 Greater than 15 ft. Not exceeding 20 ft.				Type 5	Fill Height Type 5 Greater than 20 ft. Type 6 Not Exceeding 25 ft.				Fill Height Greater than 25 ft. Not Exceeding 30 ft.			
Nom.			1401 CACCCGIII	ig 20 it.			1401 EXCCCU	ing 20 it.			TVOT EXCECUIT	ig 50 it.	
Dia.	RCCP			PVCPW	RCCP			PVCPW	RCCP			PVCPW	
(inch)	Class	PVC	CPVC	-794	Class	PVC	CPVC	-794	Class	PVC	CPVC	-794	
10 12 15	NA V	X X X	X X	NA X X	NA V-3160D V-3080D	X X	X X	NÁ X X	NA V-3790D V-3390D	X X X	** X	NA X	
18 21 24	V	X	X	X	V	X	X	X	V-3115D V	X X X			
27 30 33	V V	X	NA X NA	NA X NA	V	X	NA NA	NA NA	V	X	NA NA	NA NA	
36 42 48	iv iv	X NA NA	X NA NA	X NA NA	V	X NA NA	NA NA	NA NA	V	X NA NA	NA NA	NA NA	
54 60 66	IV IV IV	NA NA NA	NA NA NA	NA NA NA	V V IV	NA NA NA	NA NA NA	NA NA NA	V	NA NA NA	NA NA NA	NA NA NA	
72 78 84	IV IV IV	NA NA NA	NA NA NA	NA NA NA	IV IV IV	NA NA NA	NA NA NA	NA NA NA	V	NA NA NA	NA NA NA	NA NA NA	
90 96 102 108	IV IV IV	NA NA NA NA	NA NA NA NA	NA NA NA NA	IV IV IV	NA NA NA NA	NA NA NA NA	NA NA NA NA	V V V	NA NA NA NA	NA NA NA NA	NA NA NA NA	

RCCP CSP ESCP PVC CPVC PVCPW-794 Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe Concrete Sewer, Storm Drain, and Culvert Pipe Extra Strength Clay Pipe Polyvinyl Chloride (PVC) Pipe With A Smooth Interior Polyvinyl Chloride (PVC) Pipe With A Smooth Interior Polyvinyl Chloride (PVC) Profile Wall Pipe-794 Indicates this diameter pipe may be used. Not Acceptable

May also use standard strength Clay Sewer Pipe May be used if Bureau of Materials and Physical Research approves and with Manufacturers' Certification.

Note RCCP Class V - 3160D, etc. shall be furnished in accordance with AASHTO M 170 Section 6. These loads are D loads to produce a 0.01 inch crack.

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# KIND OF MATERIAL PERMITTED AND STRENGTH REQUIRED FOR THE RESPECTIVE DIAMETERS OF PIPE AND FILL HEIGHTS OVER THE TOP OF THE PIPE FOR STORM SEWERS

<b></b>				-1
	Type 7	Fill Height Greater than 9.0 m Not exceeding 10.5 m		
Nom.		Not exceeding 10.5 III		1
Dia.	RCCP			
(mm)	Class	PVC		
250 300 375	NA V-190D V-170D	X X X		Ì
450 525 600	V-160D V-150D V	X X X		
675 750 825	V	X X X		
900 1050 1200	V	X NA NA		
1350 1500 1650	V	NA NA NA		
1800 1950 2100	V	NA NA NA		
2250 2400 2550 2700	\ >> >	NA NA NA NA		

Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe
Concrete Sewer, Storm Drain, and Culvert Pipe
Extra Strength Clay Pipe
Polyvinyl Chloride (PVC) Pipe
Corrugated Polyvinyl Chloride (PVC) Pipe With A Smooth Interior
Polyvinyl Chloride (PVC) Profile Wall Pipe-794
Indicates this diameter pipe may be used.
Not Acceptable
May also use standard strength Clay Sewer Pipe
May be used if Bureau of Materials and Physical Research approves and with Manufacturers' Certification. RCCP CSP ESCP PVC CPVC PVCPW-794 X NA

RCCP Class V - 150D, etc. shall be furnished in accordance with AASHTO M 170M Section 6. These loads are D loads to produce a 0.3 mm crack. Note

# English STORM SEWERS

			MATERIAL PERMITTED AND STRENGTH REQUIRED FOR THE F PIPE AND FILL HEIGHTS OVER THE TOP OF THE PIPE FOR STORM SEWERS
	Type 7	Fill Height Greater than 30 ft. Not exceeding 35 ft.	
Nom. Dia. (inch)	RCCP Class	PVC	
10 12 15	NA V-4000D V-3575D	X X X X	
18 21 24 27 30 33	V-3300D V-3110D V	X X X	
36 42 48	V V V	X X NA NA	
54 60 66 72 78 84	V V	NA NA NA NA NA	
90 96 102 108	V	NA NA NA NA NA	

Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe
Concrete Sewer, Storm Drain, and Culvert Pipe
Extra Strength Clay Pipe
Polyvinyl Chloride (PVC) Pipe
Corrugated Polyvinyl Chloride (PVC) Pipe With A Smooth Interior
Polyvinyl Chloride (PVC) Profile Wall Pipe-794
Indicates this diameter pipe may be used.
Not Acceptable
May also use standard strength Clay Sewer Pipe
May be used if Bureau of Materials and Physical Research approves and with Manufacturers' Certification. RCCP CSP ESCP PVC CPVC PVCPW-794 ÑΑ

Note RCCP Class V - 3160D, etc. shall be furnished in accordance with AASHTO M 170 Section 6. These loads are D loads to produce a 0.01 inch crack.

## **CONSTRUCTION REQUIREMENTS**



**550.04** Excavation and Foundation. The trench shall be excavated to an elevation 100 mm (4 inches) below the bottom of the pipe and so that the flow line of the finished sewer will be at the depth and grade specified or established by the Engineer. For trench depths of less than 1.5 m (5 ft.) and when sheeting or shoring is not required, the trench shall be excavated 450 mm (18 inches) wider than the external diameter of the pipe to permit thorough tamping of the foundation material under the haunches and around the pipe. For trench depths of 1.5 m (5 ft.) or more and when sheeting or shoring is required, the trench width shall be 1 m (3 ft.) wider than the external diameter of the pipe. The trench shall be excavated so that vertical faces are maintained at least to the elevation of the top of pipe. For trench depths of 1.5 m (5 ft.) or more, the Contractor shall provide trench protection according to the applicable standards for work place safety. The Contractor shall provide to the Engineer, in writing, his/her procedures for fulfilling the safety requirements for trench protection.

If a water main is encountered during storm sewer construction, the requirements of the IEPA shall govern the horizontal and vertical separation of the water main from the storm sewer.

Well compacted, moist fine aggregate bedding material at least 100 mm (4 inches) in depth below the pipe, shall be placed the entire width of the trench and for the length of the pipe. The fine aggregate shall meet the approval of the Engineer and shall be compacted to the Engineer's satisfaction by ramming or tamping with tools approved by the Engineer. When the storm sewer outlets from an embankment or natural ground, the last 1 m (3 ft.) of the bedding and backfill at the outfall end shall be impervious material.

When pipe having bells or hubs is used, cross trenches, not more than 50 mm (2 inches) wider than the bell or hub, shall be excavated to provide uniform bearing along the length of the pipe.

If the excavation has been made deeper than necessary, the foundation shall be brought to the proper grade by the addition of well compacted bedding material.

Where a firm foundation is not encountered at the grade established due to soft, spongy or other unsuitable soil, unless other special construction methods are called for in the contract, all such unsuitable soil under the pipe and for the width of the trench shall be removed and replaced with well-compacted bedding material.

Where rock, in either ledge or boulder formation, is encountered, it shall be removed to an elevation at least 200 mm (8 inches) below the bottom of the pipe and replaced with a cushion of well compacted bedding material.

Unless otherwise directed by the Engineer, all excavated material not needed on the work shall be disposed of as specified in Article 202.03.

**550.05 Plugging Existing Sewers and Drains.** Abandoned sewers and drains, as designated by the Engineer, shall be plugged with Class SI Concrete or brick and suitable mortar to the satisfaction of the Engineer.

This work will not be paid for separately, but shall be considered as included in the contract unit price bid for the Storm Sewer items or in the absence of such items for Earth Excavation. **550.06** Laying Sewer Pipe. The Contractor shall, at his/her own expense, keep the trench free from water while the sewer is being placed and until the joint has been sealed. The laying of pipes in finished trenches shall be started at the outlet end with the spigot ends pointing in the direction of flow, and shall proceed toward the inlet end with pipes abutting and true to line and grade. The flow line at the outlet end of the pipe shall be not less than 150 mm (6 inches) above the flow line of the open ditch at the outlet.

The ends of pipes shall be carefully cleaned before the pipes are lowered into the trenches, and the pipes shall be lowered so as to avoid unnecessary handling in the trench.

As each length of pipe is laid, the mouth of the pipe shall be properly protected to prevent the entrance of earth or the bedding material. The pipes shall be fitted and matched so that when laid in the work they will form a sewer with a smooth, uniform invert. If reinforced concrete pipe is used, the word "Top" or "Bottom" may be stenciled on the inside of the pipe sections. All concrete pipe so marked shall be placed as indicated by these marks.

All joints in concrete sewer pipe shall be sealed with preformed flexible gasket or mastic joint sealer conforming to Sections 1056 or 1055 or external sealing bands conforming to Section 1057. When mastic joint sealer is used, the material shall completely fill the joint after the pipes have been brought together. PVC pipe shall be joined according to ASTM D 3034. The mastic joint sealer shall be used according to the recommendations of the manufacturer. After each joint is sealed, it shall be wiped clean on the inside. Lifting holes shall be filled with a precast concrete plug sealed and covered with mastic or mortar. Each section of pipe shall be pushed or pulled as tight as reasonably possible to the section in place to ensure tight joints. Pipe having a diameter greater than 1 m (42 inches) shall be set or "brought home" with a winch, come-a-long or other positive means.

**550.07 Backfilling.** As soon as the condition of the pipe will permit, the entire width of the trench shall be backfilled with moist fine aggregate meeting the gradations specified in Article 1003.04 to a height of at least the elevation of the center of the pipe. The fine aggregate shall be placed longitudinally along the pipe. The elevation of the backfill material on each side of the pipe shall be the same. Special care shall be taken to completely fill the space under the pipe. The fine aggregate backfill material shall be placed in 200 mm (8 inch) layers, loose measurement and compacted to the satisfaction of the Engineer by ramming or tamping with tools approved by the Engineer. The fine aggregate used for backfilling shall meet the approval of the Engineer.

The remainder of the trench and excavation shall be backfilled to the natural line or finished surface as rapidly as the condition of the sewer will permit. The backfill material shall consist of the excavated material or of trench backfill, as herein specified. All backfill material shall be deposited in the trench or excavation in such a manner as not to damage the sewer. The filling of the trench shall be carried on simultaneously on both sides of the pipe in such a manner that injurious side pressures do not occur. The backfill for trenches and excavation made in the subgrade of the proposed improvement, and for all trenches outside of the subgrade where the inner edge of the trench is within 600 mm (2 ft.) of the edge of the proposed pavement, curb, gutter, curb and gutter, stabilized shoulder or sidewalk, shall be made with trench backfill material, unless the excavated material meets the requirements of Articles 1003.01 and 1003.04.

All backfill material up to a height of 300 mm (12 inches) above the pipe shall be carefully deposited in uniform layers not exceeding 200 mm (8 inches) thick (loose measure). The material in each layer shall be firmly compacted by ramming or tamping with tools approved by the Engineer in such a manner as not to disturb or injure the pipe. The backfilling above this height shall be done by Method 1, 2 or 3 below.

When required, trench backfill material or excavated material meeting the requirements of Articles 1003.01 and 1003.04 above the first 300 mm (12 inches) above the pipe, shall be compacted by either Method 2 or Method 3 specified below, or according to Method 1, except that the compacted lifts shall not exceed 200 mm (8 inches) in thickness.

- Method 1. The material shall be deposited in uniform layers not exceeding 300 mm (12 inches) thick (loose measure), and each layer shall be compacted by ramming or tamping with tools approved by the Engineer.
- Method 2. The material shall be deposited in uniform layers not exceeding 300 mm (12 inches) thick (loose measure), and each layer shall be either inundated or deposited in water.
- Method 3. The trench shall be backfilled with loose material, and settlement secured by introducing water through holes jetted into the backfill to a point approximately 600 mm (2 ft.) above the top of the pipe. The holes shall be spaced as directed by the Engineer but shall be no farther than 2 m (6 ft.) apart.

The water shall be injected at a pressure just sufficient to sink the holes at a moderate rate of speed. The pressure shall be such that the water will not cut cavities in the backfill material nor overflow the surface. If water does overflow the surface, it shall be drained into the jetted holes by means of shallow trenches.

Water shall be injected as long as it will be absorbed by the backfill material and until samples taken from test holes in the trench show a satisfactory moisture content. The Contractor shall bore the test holes not more than 15 m (50 ft.) apart and at such other locations in the trench designated by the Engineer. As soon as the watersoaking has been completed, all holes shall be filled with soil and compacted by ramming with a tool approved by the Engineer.

Backfill material which has been watersoaked shall be allowed to settle and dry for at least 10 days before any surface course or pavement is constructed on it. The length of time may be altered, if deemed desirable, by the Engineer. Where the inner edge of the trench is within 600 mm (2 ft.) of the edge of the proposed pavement, curb, gutter, curb and gutter, stabilized shoulder or sidewalk, the provisions of this paragraph shall also apply.

At the end of the settling and drying period, the crusted top of the backfill material shall be scarified and, if necessary, sufficient backfill material added, as specified in Method 1, to complete the backfilling operations.

The method used for backfilling and compacting the backfill material shall be the choice of the Contractor. If the method used does not produce results satisfactory to the Engineer, the Contractor will be required to alter or change the method being used so that the resultant backfill will be satisfactory to the Engineer. Should the Contractor be required to alter or change the method being used, no additional compensation

will be allowed for altering or changing the method.

When sheeting and bracing have been used, sufficient bracing shall be left across the trench as the backfilling progresses to hold the sides firmly in place without caving or settlement. This bracing shall be removed as soon as practicable. Any depressions which may develop within the area involved in the construction operation due to settlement of the backfilling material shall be filled in a manner meeting the approval of the Engineer.

When the Contractor constructs the trench with sloped sides or benched according to the requirements of Article 550.04, backfilling for the full width of the excavation shall be as hereinbefore specified, except no additional compensation will be allowed for trench backfill material required outside the vertical limits of the specified trench width.

Whenever excavation is made for installing sewer pipe across earth shoulders or private property, the topsoil disturbed by excavation operations shall be replaced as nearly as possible in its original position, and the whole area involved in the construction operations shall be left in a neat and presentable condition.

When using any PVC pipe the pipe shall be backfilled with a moist fine aggregate to 300 mm (1 ft.) over the top of the pipe and compacted to a minimum of 85% of standard lab density.

When reinforced concrete pipes are used, the backfill shall be compacted to a minimum of 85% of standard lab density when the trench is within 600 mm (2 ft.) of the pavement structure.

Deflection Testing for Storm Sewers. All PVC storm sewers will be tested for deflection not less than 30 days after the pipe is installed and the backfill compacted.

For PVC storm sewers with diameters 600 mm (24 inches) or smaller, a mandrel drag shall be used for deflection testing. For PVC storm sewers with diameters over 600 mm (24 inches), deflection measurements other than by a mandrel drag shall be used.

Where the mandrel is used, the mandrel shall be furnished by the Contractor and pulled by hand through the pipeline with a suitable rope or cable connected to each end. Winching or other means of forcing the deflection gauge through the pipeline will not be allowed.

The mandrel shall be of a shape similar to that of a true circle enabling the gauge to pass through a satisfactory pipeline with little or no resistance. The mandrel shall be of a design to prevent it from tipping from side to side and to prevent debris build-up from occurring between the channels of the adjacent fins or legs during operation. Each end of the core of the mandrel shall have fasteners to which the pulling cables can be attached. The mandrel shall have 9, various sized fins or legs of appropriate dimension for various diameter pipes. Each fin or leg shall have a permanent marking that states its designated pipe size and percent of deflection allowable.

The outside diameter of the mandrel shall be 95% of the base inside diameter, where the base inside diameter is:

For all PVC pipe: as defined using ASTM D 3034 methodology.

If the pipe is found to have a deflection greater than that specified, that pipe section shall be removed, replaced, and retested.

**550.08 Method of Measurement.** Storm sewers of the different types and diameters will be measured for payment in place in meters (feet).

When the storm sewer enters a manhole, inlet or catch basin, the measurement will end at the inside wall of the manhole, inlet or catch basin. Allowance will be made for the length of pipe necessary to permit the pipe to meet the sides of the manhole. No payment for storm sewer will be made through an inlet or manhole where the inlet or manhole is paid for as a separate item. However, when the storm sewer is continuous and the inlet is constructed on top of the storm sewer, the measurement will be from end to end of storm sewer with a deduction made for the tee section which is paid for separately. Measurement of the pipe will not be made by counting lengths of pipe or joints.

Trench backfill will be measured for payment as specified in Article 208.03.

Excavation in rock will be measured for payment as specified in Article 502.14.

**550.09 Basis of Payment.** This work will be paid for at the contract unit price per meter (foot) for STORM SEWERS, of the class, type, and diameter specified, and of the kind of material when specified.

Trench backfill will be paid for according to Article 208.04.

Excavation in rock will be classified and paid for according to Article 502.15 for Rock Excavation for Structures.

Removal and replacement of unsuitable material below plan bedding grade will be paid for according to Article 109.04.

## SECTION 551, STORM SEWER REMOVAL AND INSTALLATION

**551.01 Description.** This work shall consist of the removal and or installation of storm sewers, including laterals.

#### CONSTRUCTION REQUIREMENTS

**551.02 Removal.** Existing storm sewers shall be removed so that all pipe considered suitable by the Engineer for future use shall be salvaged. The location and manner of storage of salvaged material shall be as directed by the Engineer. Any of the material having salvage value which has been damaged by the Contractor shall be replaced by the Contractor, at his/her own expense, with new pipe of the same kind and size. Material not suitable for salvage shall be disposed of by the Contractor according to Article 202.03.

Trenches resulting from the removal of storm sewers shall be backfilled according to the applicable requirements of Article 550.07.

**551.03 Installation.** Suitable pipe salvaged from storm sewer removal shall be used when available. All new materials shall meet the requirements of Articles 550.02 and 550.03.

When salvaged pipe is available for use, any new material required shall be of the same kind as the salvaged pipe.

Storm sewer installation shall be performed according to the applicable requirements of Section 550. The Contractor, at his/her own expense, shall replace pipe damaged by the Contractor with pipe of the same kind and size.

**551.04 Method of Measurement.** Storm sewer removal of the various diameters will be measured for payment in meters (feet), measured as removed.

Storm sewer installation of the different diameters will be measured for payment in place in meters (feet) according to the applicable requirements of Article 550.08.

Excavation in rock will be measured for payment as specified in Article 502.14.

Trench backfill will be measured for payment as specified in Article 208.03.

**551.05 Basis of Payment.** Storm sewer removal will be paid for at the contract unit price per meter (foot) for STORM SEWER REMOVAL, of the diameter specified, which price shall include all excavation and backfilling, and removing and salvaging the pipe.

Storm sewer installation will be paid for at the contract unit price per meter (foot) for STORM SEWER INSTALLATION, of the diameter specified, which price shall include all materials except furnishing new pipe and trench backfill, all excavation except excavation in rock and excavation to remove unsuitable material below plan bedding grade, backfilling, and all sheeting or shoring required.

The furnishing of all new pipe, except for replacement of pipe damaged by the Contractor, will be paid for according to Article 109.04.

Excavation in rock will be paid for as specified in Article 502.15 for Rock Excavation for Structures.

Trench backfill will be paid for as specified in Article 208.04.

Removal and replacement of unsuitable material below plan bedding grade will be paid for according to Article 109.04.

#### SECTION 552, STORM SEWERS JACKED IN PLACE

**552.01 Description.** This work shall consist of furnishing and installing, by jacking, storm sewers of the required inside diameter at locations shown on the plans.

**552.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 - Materials:

	Item Artic	cle/Section
(a)	Reinforced Concrete Culvert, Storm Drain and	
	Sewer Pipe (Note 1)	1040.03
(b)	Reinforced Concrete Elliptical Culverts, Storm Drain and	
	Sewer Pipe (Note 1)	1040.05

Note 1. Tongue and Groove Type Joint. Not less than a Class IV Pipe.

**552.03 Traffic Control.** The road shall be kept open to to traffic according to Article 701.05(d)(3).

#### **CONSTRUCTION REQUIREMENTS**

**552.04 General.** Storm sewers, of the type and size specified, shall be jacked in a continuous operation. The construction may be accomplished by jacking the storm sewer, or if the Contractor elects, a metal liner of sufficient strength and size first, then the storm sewer installed inside the liner. If the liner is used, it shall remain in place to support the embankment, and the voids between the liner and the sewer pipe shall be completely filled with sand or grout mixture as approved by the Engineer. The diameter of the metal liner, if used, shall not exceed the outside diameter of the storm sewer by more than 150 mm (6 inches).

The Contractor may shorten the length of storm sewer to be jacked by open cutting and sheeting, shoring or bracing the excavation outside the roadway limits. No open cutting shall be permitted inside the shoulder lines. If continuous jacking operation cannot be maintained, the Contractor shall take the necessary precautions for not allowing the jacked pipe to freeze in place.

All sheeting, bracing, shoring, jacking frame, guide rails, backstop, shields, sleeves and other materials necessary for the complete installation of the storm sewer shall be of sufficient strength to support the loads that are to be imposed on them.

The types, sizes and number of jacks, jacking pit and other equipment used shall be such as to exert sufficient force to overcome the greatest resistance to be encountered, considering both weight of the pipe or liner and the friction on its exterior surface. Lubricants, if required, may be used to decrease the frictional resistance on the exterior surface of the pipe being jacked. Suitable lubricants may be applied directly to the surface or through 15 mm (1/2 inch) nipples through holes drilled in the cutting shield at the lead pipe.

Care shall be taken in arranging the jacking equipment and struts to ensure that thrust is applied parallel with the centerline of the pipe or liner or as approved by the Engineer. A jacking head or collar shall be used to apply pressure from the jack to the pipe or liner. Pressure applied with the metal of the jack in direct contact with concrete pipe will not be permitted.

A cutting edge at least 15 mm (1/2 inch) greater in diameter than the pipe or liner being jacked shall be provided for the leading pipe or liner. The upper half of the cutting edge shall project beyond the pipe or liner end to support the embankment. Excavation within the jacked pipe or liner shall be performed in such a manner as to not increase the excavated diameter larger than the pipe or liner being jacked. Excavation shall not be carried beyond the end of the cutting edge of the pipe or liner. Any holes provided in the lead pipe to attach the cutting edge shall be properly filled with plug and mastic as approved by the Engineer after completion of the jacking operation and removal of cutting edge.

**552.05 Joints.** As each succeeding pipe section is placed against the previously jacked pipe, a 15-mm (1/2-inch) manila rope or other suitable material shall be inserted throughout the entire groove of the joint and set in place with asphalt mastic. The opening on the inside of the pipe shall be mortared with a mixture composed of one part cement to three parts sand, by volume, based on dry materials, after the complete sewer has been jacked in place. Any other method of jointing must

be approved by the Engineer prior to the start of construction.

- **552.06** Accuracy of Placement. The alignment and elevation of the forward end of the pipe shall be checked at regular intervals as work proceeds and appropriate measures immediately taken to correct any observed deviation. When the Contractor elects to jack a metal liner prior to installing the storm sewer, all earth and other foreign material shall be removed from inside the liner. The storm sewer sections shall be installed by jacking the sections through the liner.
- **552.07 Method of Measurement.** Storm sewers jacked in place of the different diameters will be measured for payment in meters (feet) in place.

Excavation in rock will be measured for payment as specified in Article 502.14.

**552.08 Basis of Payment.** This work will be paid for at the contract unit price per meter (foot) for STORM SEWERS JACKED IN PLACE, of the diameter specified, which price shall include the storm sewer, metal liner if used, including backfilling all voids between the storm sewer and metal liner, all other materials and equipment necessary to install the storm sewer and all excavation except excavation in rock.

Excavation in rock will be paid for as specified in Article 502.15 for Rock Excavation for Structures.

#### UTILITIES

#### **SECTION 560. CAST IRON SOIL PIPE**

- **560.01 Description.** This work shall consist of constructing cast iron soil pipe of the required inside diameter.
- **560.02 Materials.** Materials shall meet the requirements of the following Article of Section 1000 Materials:

#### **CONSTRUCTION REQUIREMENTS**

**560.03 General.** Construction requirements shall conform to Section 550 with the following exceptions:

The pipe shall be laid with its spigot end lacking 5 mm (1/4 inch) of being driven full into the bell. Gaskets of clean, sound hemp yarn braided or twisted and tightly driven shall be used to pack the joints, followed by caulking with pure soft lead of the best quality for the purpose, so as to make a tight and permanent joint. All pipes shall be carefully cleaned before laying, and shall be left clean and in working order. The pipe shall have a solid bearing throughout its entire length. If it becomes necessary to cut the pipe, it shall be cut in such a manner that the ends will be square with the axis of the pipe.

**560.04 Method of Measurement.** Cast iron soil pipe of the various diameters will be measured for payment in meters (feet), measured in place.

Excavation in rock will be measured for payment as specified in Article 502.14.

Trench backfill will be measured for payment as specified in Article 208.03.

**560.05** Basis of Payment. This work will be paid for at the contract unit price per meter (foot) for CAST IRON SOIL PIPE, of the diameter specified, which price shall include all pipe fittings, joint materials and all excavation, except excavation in rock.

Excavation in rock will be paid for as specified in Article 502.15 for Rock Excavation for Structures.

Trench Backfill will be paid for as specified in Article 208.04.

## **SECTION 561. WATER MAIN**

- **561.01 Description.** This work shall consist of constructing water main of the required material and inside diameter.
  - **561.02 Materials.** Materials shall be as shown in the contract.

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#### CONSTRUCTION REQUIREMENTS

- **561.03 General.** Installation methods shall conform to the manufacturer's recommendations for the type of pipe being installed with the following exceptions:
  - (a) Excavation and Foundation. The applicable requirements of Article 550.04 shall govern the performance of this work.
  - (b) Requirements for the Protection of Water Mains from Sewers. The requirements of the IEPA shall govern the horizontal and vertical separation of water mains from sewers.
  - (c) Backfilling. The applicable requirements of Article 550.07 shall govern the performance of this work except that backfilling shall not be done in freezing weather without written permission of the Engineer, and it shall not be made with frozen material. No backfill shall be made where the material already in the trench is frozen.

Backfilling around joints shall not be made until the hydrostatic tests have been made and any leaks have been repaired.

- **561.04 Hydrostatic Tests.** Hydrostatic tests will be performed according to Section 13 of the American Water Works Association Specifications, Designation: AWWA C600. The water main will be subjected to the hydrostatic pressure and leakage tests specified in the Special Provisions. Water for making the hydrostatic and leakage tests shall be furnished by the Contractor at his/her own expense and shall be of satisfactory bacteriological quality for drinking purposes.
- **561.05 Disinfection of Water Main.** Upon completion of the newly laid water main, the water main shall be disinfected according to the American Water Works Association, Procedure Designation: AWWA C651.
- **561.06 Method of Measurement.** Water main of the various diameters will be measured for payment in meters (feet), measured in place.

Excavation in rock will be measured for payment as specified in Article 502.14.

Trench backfill will be measured for payment as specified in Article 208.03.

**561.07 Basis of Payment.** This work will be paid for at the contract unit price per meter (foot) for WATER MAIN, of the diameter specified, which price shall include all pipe fittings, joint materials, the hydrostatic tests, disinfecting of the water main and all excavation, except excavation in rock.

Excavation in rock will be paid for as specified in Article 502.15 for Rock Excavation for Structures.

Trench Backfill will be paid for as specified in Article 208.04.

#### SECTION 562. WATER SERVICE LINE

**562.01 Description.** This work shall consist of constructing water service line of the required material and inside diameter.

**562.02 Materials.** All materials shall be as shown on the plans or as included in the Special Provisions.

#### CONSTRUCTION REQUIREMENTS

**562.03 General.** Any excavation required shall be only sufficient to install the water service line.

Installation of the water service line shall be made in a manner meeting the approval of the Engineer.

The requirements of the IEPA shall govern the horizontal and vertical separation of water service lines from sewers.

The applicable requirements of Article 550.07 shall govern the backfilling, except that backfilling shall not be done in freezing weather without permission of the Engineer, and it shall not be made with frozen material. No backfill shall be made where the material already in the trench is frozen.

**562.04 Method of Measurement.** Water service line of the various diameters will be measured for payment in meters (feet), measured in place.

Excavation in rock will be measured for payment as specified in Article 502.14.

Trench backfill will be measured for payment as specified in Article 208.03.

**562.05 Basis of Payment.** This work will be paid for at the contract unit price per meter (foot) for WATER SERVICE LINE, of the internal diameter specified, which price shall include all pipe fittings, joint materials and all excavation, except excavation in rock.

Excavation in rock will be paid for as specified in Article 502.15 for Rock Excavation for Structures.

Trench Backfill will be paid for as specified in Article 208.04.

# SECTION 563. ADJUSTING SANITARY SEWERS AND WATER SERVICE LINES

- **563.01 Description.** This work shall consist of adjusting sanitary sewers and water service lines, where required by the construction of the improvement.
- **563.02 Materials.** Materials shall be as shown on the plans or as included in the Special Provisions. Materials for replacement shall be the same kind as, or equal to, the material being replaced.

#### **CONSTRUCTION REQUIREMENTS**

**563.03 General.** When the contract includes information concerning the number, locations, and lengths of sanitary sewers and water service lines which are to be adjusted, such information represents the best knowledge of the Department and is included for the convenience of the bidder. The Department assumes no responsibility whatever in respect to the sufficiency or accuracy of the information shown. It shall be the Contractor's responsibility to determine the exact locations of

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all such installations. The Contractor shall also obtain from the governmental agency or utility company responsible for the respective installations, detailed information concerning the locations of the installations. The work shall conform to the Standard Specifications for Water and Sewer Main Construction in Illinois. No additional compensation will be allowed the Contractor due to any delays or inconvenience resulting from these requirements, nor on account of any special construction methods required in prosecuting the Contractor's work.

When a Sanitary District, Municipality or Water District has jurisdiction of a sanitary sewer or water service line, the work shall be performed as prescribed by the Sanitary District, Municipality or Water District and shall meet the approval of its Engineer.

If the Contractor damages any sanitary sewer or water service line not requiring adjustment, or any other underground structure or utility, the Contractor shall replace or repair it as required by the Engineer, and no additional compensation will be allowed.

When a sanitary sewer or water service line is to be adjusted, the Contractor shall remove it carefully to prevent damage to the pipe. Any material, including fittings, which is not satisfactory for reuse, in the opinion of the Engineer, shall be replaced and payment will be made for the replacement material according to Article 109.04. Any material, including fittings, which is damaged by the Contractor due to his/her negligence, shall be replaced by the Contractor at his/her own expense.

All material removed and not reused shall become the property of the Contractor. The salvage value of this material shall be reflected in unit price bid for the items involved.

- **563.04** Adjusting Sanitary Sewers. The work necessary to adjust sanitary sewers shall be performed according to the applicable requirements of Section 550.
- **563.05** Adjusting Water Service Lines. The work necessary to adjust water service lines shall be performed according to the applicable portions of Section 562.

Any water service line, other than copper, which is or will be under a base or surface course and which requires adjustment, shall be replaced with copper pipe conforming to the requirements of Article 1006.33.

**563.06 Method of Measurement.** Adjusting sanitary sewers and water service lines will be measured for payment in meters (feet) complete in place. The length of sanitary sewers, 200 mm (8 inches) in diameter or less, and those over 200 mm (8 inches), shall be measured separately.

Excavation in rock will be measured for payment as specified in Article 502.14.

Trench backfill will be measured for payment as specified in Article 208.03.

**563.07 Basis of Payment.** This work will be paid for at the contract unit prices per meter (foot) for ADJUSTING SANITARY SEWERS, (200-MM (8-INCH DIAMETER OR LESS), ADJUSTING SANITARY SEWERS, (OVER 200-MM (8-INCH) DIAMETER) and ADJUSTING WATER SERVICE LINES; which prices shall include all joint materials, making all connections, excavation except excavation in rock, and backfilling.

Excavation in rock will be paid for as specified in Article 502.15 for Rock Excavation for Structures.

Trench Backfill will be paid for as specified in Article 208.04.

The furnishing of materials required to replace material declared unsatisfactory by the Engineer and new materials necessary to complete the work, except as above noted, will be paid for according to Article 109.04.

#### **SECTION 564. MOVING FIRE HYDRANTS**

**564.01 Description.** All existing fire hydrants which interfere with the construction of the proposed improvement shall be relocated or adjusted as indicated on the plans or required by the Engineer. This item includes fire hydrants with auxiliary valves and the adjustment of the fire hydrants and the auxiliary valves to the new elevations required by the proposed improvement.

#### **CONSTRUCTION REQUIREMENTS**

**564.02 General.** Fire Hydrants shall be set on a firm foundation and shall be thrust blocked according to the details shown on the plans and as directed by the Engineer.

Thrust blocking shall consist of Class SI Concrete cast against the fittings and the undisturbed earth on the side where the thrust is expected to occur. A minimum of 0.2 m³ (1/4 cu. yd.) of concrete shall be used for the thrust block. The dimensions of the thrust block shall be determined by the Engineer. Blocking shall be placed such that the pipe, fittings and joints shall be accessible for future repair.

Upon completion of relocating or adjusting the fire hydrant, it shall be tested and disinfected as specified in Articles 561.04 and 561.05.

The hole formed by the removal of a fire hydrant and the remaining excavated area around the relocated fire hydrant shall be backfilled with fine aggregate.

Any fire hydrant damaged by the Contractor shall be repaired at his/her own expense.

The work shall be performed in a manner approved by the Engineer of the municipality or the Water District.

**564.03** Basis of Payment. This work will be paid for at the contract unit price each for FIRE HYDRANTS TO BE MOVED. When fire hydrants are not located or relocated as shown on the plans or when hydrants not shown on the plans are to be moved, the work will be paid for according to Article 109.04.

# SECTION 565. MOVING DOMESTIC METER VAULTS AND WATER SERVICE BOXES

**565.01 Description.** All domestic meter vaults and water service boxes which are to be moved shall be removed and reset back of the proposed curb, or as directed by the Engineer.

# Moving Domestic Meter Vaults and Water Service Boxes

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The hole formed by the removal of the domestic meter vault or water service box shall be backfilled with fine aggregate.

Any domestic meter vault or water service box, including the stop cocks, which are damaged by the Contractor shall be repaired at his/her own expense.

The work shall be performed in a manner approved by the Engineer of the municipality, or the Water District.

**565.02** Basis of Payment. This work will be paid for at the contract unit price each for DOMESTIC METER VAULTS TO BE MOVED or DOMESTIC WATER SERVICE BOXES TO BE MOVED, which price shall be payment in full for all excavation; furnishing all materials, except any necessary pipe; wiping joints; backfilling, including fine aggregate; and disposal of surplus materials.

#### **MISCELLANEOUS**

# SECTION 580. MEMBRANE WATERPROOFING FOR RAILWAY STRUCTURES

**580.01 Description.** This work shall consist of furnishing, transporting and placing all materials required to construct a membrane waterproofing system on railway structures.

The membrane waterproofing shall be of the bituminous or butyl rubber type as specified on the plans.

**580.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 - Materials:

	ltem	Article/Section
(a)	Waterproofing Materials (Note 1)	
(b)	Fine Aggregate	1003.05

Note 1. The bitumen used shall be asphalt. The bitumen for mopping and for the protective cover shall be the same type as that with which the fabric is treated.

#### **CONSTRUCTION REQUIREMENTS**

**580.03 General.** Surfaces to be waterproofed shall be smooth and free from projections which might damage the waterproofing membrane and there shall be no depressions in horizontal surfaces of the finished waterproofing. Projections or depressions on the surface on which the membrane is to be applied that may cause injury to the membrane shall be removed or filled as directed by the Engineer. The surface shall be cleaned of dust, dirt, grease and loose particles, and shall be dry before the waterproofing is applied. Concrete surfaces shall not be waterproofed until a period of at least 7 days has elapsed after the placing of the concrete, unless otherwise approved by the Engineer.

There shall be no depressions or pockets in horizontal surfaces of the finished waterproofing. The membrane shall be carefully turned into drainage fittings. Special care shall be taken to make the waterproofing effective along the sides and ends of girders and at stiffeners, gussets and all other plates where the membrane terminates.

Bituminous membrane waterproofing shall not be applied when the atmospheric temperature is below 10  $^{\circ}$ C (50  $^{\circ}$ F.) and butyl rubber membrane shall not be applied when the atmospheric temperature is below -12  $^{\circ}$ C (10  $^{\circ}$ F.), without written permission of the Engineer.

Surfaces of concrete or steel that are to be waterproofed shall be given one coat of Asphalt Primer: RC-70, before the first mopping of Asphalt: AWP, except that at construction and expansion joints where insulation is to be used, the surfaces shall not be coated with primer. The primer shall be applied to the surface in a uniform coating and may be applied without heating. A minimum of 4 L (1 gal.) of primer per 10 m<sup>2</sup> (100 sq. ft.) of surface shall be used. The priming coat shall be applied at least 24 hours before applying the waterproofing membrane and it shall be dry before the first mopping of bitumen is applied.

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The primer shall be omitted for a width of 225 mm (9 inches) on each side of construction and expansion joints and a strip of insulating paper 450 mm (18 inches) wide shall be laid thereon before the waterproofing is applied. Insulating paper shall be a waterproof paper weighing not less than 0.5 kg/m² (10 lbs. per 100 sq. ft.).

Expansion joints and grooves shall be dry and clean and, shall be filled with plastic cement. Expansion joints and grooves filled with plastic cement shall be overfilled to allow for shrinkage.

**580.04 Membrane Application.** Bituminous and butyl rubber membranes shall be applied as specified.

(a) Bituminous Membrane. On surfaces that are vertical, or nearly so, the strips of fabric shall be laid vertically or with the slope; on other surfaces the strips shall be laid horizontally, beginning at the lowest part of the surface to be waterproofed. Sufficient fabric shall be allowed for anchorage at the upper edge of the surface to be waterproofed.

Surfaces to be waterproofed shall be mopped in sections. While the first mopping of bitumen is still hot, a strip of fabric shall be laid on the mopping and pressed into place. Each mopping thereafter shall be applied so that it will completely cover and seal the fabric. The amount of bitumen used for each mopping shall be not less than 1.8 L/m² (4 1/2 gal. per 100 sq. ft.) of surface. The bitumen for mopping shall be heated to a temperature which will permit uniform application. Asphalt shall not be heated above a temperature of 175 °C (350 °F.).

Asphalt: AWP shall be used for mopping asphalt saturated cotton fabric.

Application of bituminous membrane shall be started by mopping a section of the surface 50 mm (2 inches) wider than 1/3 of the width of fabric. On this hot mopping, a 1/3 width of fabric shall be laid. The top surface of this fabric and an adjacent section of the surface 50 mm (2 inches) wider than 1/3 width of fabric shall then be mopped. On this hot mopping, a 2/3 width of fabric shall be laid completely covering the first strip. The top surface of this fabric and an adjacent section of the surface 50 mm (2 inches) wider than 1/3 width of fabric shall then be mopped. On this hot mopping shall be laid a full width of fabric completely covering the first and second strips. The top surface of this fabric and adjacent section, the width of 1/3 width of the fabric, shall then be mopped. On this hot mopping, the second full strip of fabric shall be laid lapping the first 1/3 width of the fabric at least 50 mm (2 inches). Thereafter, full widths of fabric shall be laid in hot moppings of bitumen and in such manner that each strip will lap the third preceding strip at least 50 mm (2 inches). Side laps shall be not less than 50 mm (2 inches) and end laps not less than 300 mm (12 inches).

The bituminous membrane shall be free from punctures, pockets or folds, and patching shall not be done without the permission of the Engineer. Where patching is permitted for defective waterproofing, the first ply shall extend at least 300 mm (12 inches) beyond the defective portion. The second and each succeeding ply of the patch shall extend at least 75 mm (3 inches) beyond the preceding ply.

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The work shall be regulated so that at the end of the day all fabric that has been laid shall have received the final coat of bitumen, except that the fabric for making the lap shall not be mopped with bitumen until the joint is to be completed. With the approval of the Engineer, spraying will be permitted in lieu of mopping.

(b) Butyl Rubber Membrane. Butyl rubber membrane sheets shall be laid and secured in a hot mopping of bitumen applied over the primed surfaces. When the surface has been primed using RC-70, the mopping shall be with asphalt: AWP. An adhesive, compatible to the membrane and other materials, may be used in lieu of the hot mopping of bitumen, at the option of the Contractor. If adhesive is used, it shall be applied to the areas to be waterproofed in a thin layer with a squeegee at a rate of 0.4 L/m² (1 gal. per 100 sq. ft.).

Membrane sheets shall first be positioned and drawn tight without stretching. Half of the membrane sheet shall then be uniformly rolled up in a direction away from the starting edge or subsequent splice. The bitumen or adhesive shall now be applied to the exposed area. If adhesive is used, it shall be allowed to dry so as not to stick to a dry finger touch. The membrane shall then be unrolled and pressed firmly and uniformly in place, using care to avoid trapping air. The same procedure shall be used for the remaining half of the membrane sheet. Wrinkles and buckles shall be avoided. Each succeeding sheet shall be positioned to fit the previously installed sheet and spliced.

Splices shall be of tongue-and-groove or lap type. All seam, lap and splice areas shall be cleaned with heptane, hexane, toluene, trichlorethlene or white gasoline, using a clean cloth, mop or similar synthetic cleaning device. Rubber cement shall be spread continuously on seam, lap and splice areas at a uniform rate of not less than 0.8 L/m² (2 gal. per 100 sq. ft.). After the rubber cement is allowed to dry until it will not stick to a dry finger touch, butyl gum tape shall be applied to the cemented area of membrane. The tape shall be extended at least 3 mm (1/8 inch) beyond edges of splice and lap areas. The tape shall be rolled or pressed firmly into place so full contact is obtained. Bridging and wrinkles shall be avoided. Corner splices shall be reinforced with two continuous layers of rubber membrane over one layer of butyl tape.

All projecting pipe, conduits and sleeves passing through butyl rubber membrane waterproofing shall be flashed with prefabricated or field-fabricated boots or fitted coverings, as necessary to provide watertight construction. Butyl gum tape shall be used between layers of rubber membrane.

Any holes in the membrane sheeting shall be patched with a minimum overlap of 100 mm (4 inches) and according to the manufacturer's instructions. During construction, care shall be exercised to prevent damage to the membrane by workers or equipment.

**580.05 Protective Cover.** The protective cover shall be placed over the membrane as soon as practicable after the membrane has been laid. Dirt and other

# Membrane Waterproofing For Railway Structures

foreign material shall be removed from the surface of the membrane before the protective cover is placed.

At expansion joints of decks protected with butyl rubber membrane, a strip of anti-bonding paper 450 mm (18 inches) wide shall be laid above and below the membrane before the protective cover is applied.

One of the following methods of protection shall be used:

- (a) A layer of asphalt plank not less than 30 mm (1 1/4 inches) thick laid in a mopping of asphalt with all joints filled with asphalt.
- (b) A layer or layers of asphaltic panels not less than 20 mm (3/4 inches) in total thickness.

For bituminous membrane, the asphalt plank protection shall be laid in hot Asphalt: AWP. The asphalt shall be applied at the rate of not less than 2 L/m² (5 gal. per 100 sq. ft.) of surface. As successive planks are laid, the edges and ends of adjacent planks already laid shall be coated heavily with hot asphalt. The planks shall be laid tight against those previously laid so that the asphalt will completely fill the joints and be squeezed out at the top. After all planks are laid, any joints not completely filled shall be filled with hot asphalt. The ends of adjacent planks shall be staggered.

For butyl rubber membrane, the asphalt plank shall be laid in a coating of bonding adhesive. The bonding adhesive shall be the same as that used for securing the membrane to the deck. The adhesive shall be applied at a rate of not less than 0.4 L/m<sup>2</sup> (1 gal. per 100 sq. ft.). Voids between the joints shall be filled with a compatible material.

Asphaltic panels are available in various thicknesses. To obtain the thickness of 20 mm (3/4 inch) required, the recommended application is in two layers with the joints staggered. The panels shall be laid tight jointed with an approved adhesive. For bituminous membrane, the asphaltic panels shall be laid in hot Asphalt: AWP and for butyl rubber membrane, the panels shall be laid in a coating of bonding adhesive. The application rate shall be the same as previously specified for asphalt planks. Any voids between the panels shall be filled with a material compatible to both the membrane and the panel.

When asphaltic panels are used as a protective cover, a 50-mm (2-inch) layer of fine aggregate shall be placed over the panels as a cushion prior to placement of ballast. The cost of this cushion shall be included in the bid price for membrane waterproofing.

## 580.06 Method of Measurement.

- (a) Contract Quantities. The requirements for the use of Contract Quantities shall conform to Article 202.07(a).
- (b) Measured Quantities. The membrane waterproofing will be measured for payment in place, and the area computed in square meters (square feet). The area for measurement will include only the surface of the membrane waterproofing covered with a protective cover.

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# Membrane Waterproofing For Railway Structures

**580.07 Basis of Payment.** This work will be paid for at the contract unit price per square meter (square foot) for MEMBRANE WATERPROOFING.

## SECTION 581. WATERPROOFING MEMBRANE SYSTEM

- **581.01 Description.** This work shall consist of furnishing and placing a waterproofing membrane system over a properly prepared concrete bridge deck prior to placing of the bituminous concrete surface course.
- **581.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 Materials:

ICICS	of Section 1000 - Materials.	
	Item	Article/Section
(a)	Water	1002
		1061

The waterproofing membrane system shall consist of a penetrating primer, a built-up coal tar pitch emulsion membrane with two plies of coated glass fabric, and a 15-mm (1/2-inch) thick asphalt sand seal protection layer.

#### CONSTRUCTION REQUIREMENTS

- **581.03 General.** All methods employed in performing the work and all equipment, tools and machinery used for handling materials and executing any part of the work shall be subject to approval of the Engineer before the work is started, and whenever found unsatisfactory, shall be changed or improved as required. All equipment, tools, machinery and containers used shall be kept clean and maintained in a satisfactory condition.
- **581.04** Preparation of Concrete Deck. All surfaces which are to be covered shall be thoroughly cleaned by the use of air jets, water jets, mechanical sweeper, hand brooms, or other approved methods, or as required by the Engineer until the surface is free of all sand, clay, dust, salt deposits, and all loose or foreign matter. Any accumulations of oil or grease shall be scraped off the surface of the roadway after which those areas shall be cleaned with a strong caustic solution, the residue of which shall be thoroughly flushed away with clean water before application of the primer.

All cleaned areas shall be primed without delay as soon as they are dry. All dust and dirt shall be blown off with air jets immediately preceding application of primer. Any unusually sharp concrete edges on the deck surface which could puncture the membrane shall be corrected in a manner satisfactory to the Engineer prior to application of the primer. Exposed aggregate or rough spots shall be smoothed.

A 15 mm to 20 mm (1/2 to 3/4 inch) fillet of concrete or epoxy grout shall be placed in the cove area between curb, parapet, median and expansion dam faces and the deck surface to prevent a void area where the membrane turns up the vertical face.

Concrete surfaces, structural steel, railing, passing vehicles, etc. shall be protected to prevent their being defaced by primer or other materials being used. Should defacement occur, the Contractor shall clean surfaces on the structure to the satisfaction of the Engineer and be solely responsible and liable for damage to

passing vehicles. From the time the bridge deck is cleaned and prepared for the prime coat until the bituminous concrete is spread and compacted, the only traffic permitted on the area being treated shall be the necessary men and equipment to perform the work required.

**581.05** Weather and Moisture Limitations. Weather and Moisture Limitations. Work shall not be done during wet weather conditions, nor when the deck and ambient air temperatures are below 7 °C (45 °F.). The deck shall be surface-dry at the time of the application of the primer. The membrane shall not be placed until at least 28 days after deck-concrete placement on new structures unless otherwise directed. On existing structures where the normal traffic flow is interrupted by the project work, as much drying time after the curing period shall be allowed as is feasible before membrane placement.

**581.06 Application of Membrane System.** Pressure distributors used for the application of the tar emulsion shall be self-propelled, equipped with pneumatic tires, and capable of applying 0.4 to 0.5 L/m<sup>2</sup> (0.08 to 0.10 gal. per sq. yd.) of tar emulsion over the required width of application. Distributors shall be equipped with removable manhole covers, tachometers, pressure gauges and volume measuring devices.

Mixing and agitating equipment furnished shall be either a portable power mixer or a tank-type power mixer. A portable mixer for use in drums shall have sufficient power and propeller blades shaped to thoroughly mix and pull the material upward from the bottom of the drum. Mixing in tanks may be done in round bottom tanks equipped with a power driven mixer of sufficient capacity to maintain the emulsion in suspension.

The primer and full membrane shall extend up the curb faces and other vertical barriers to at least the elevation of the top of the surfacing. The lips of drain openings and edges of open joints, deck slab and other openings at deck level shall be completely sealed by extending the full waterproofing course over the lip or edge.

The penetrating primer shall be applied by spraying, preferably with high pressure hydraulic equipment using hand-held spray bars that permit close control of the quantity applied. Applied at the rate of approximately 0.05 L/m² (0.01 gal./sq. yd.), the quantity shall be controlled to produce a "brown coat" filling all pores and depressions but devoid of lakes or pools showing a solid film when dried out. The purpose of the primer is to neutralize the concrete surface and not to produce a membrane film by itself.

Primer shall not be diluted unless ordered by the Engineer. A distributor truck shall not be used to apply the primer unless its performance has been demonstrated and its use approved by the Engineer. Surfaces shall be dry when primer is applied, and the weather and atmospheric conditions favorable for a drying period of at least four hours. Care shall be taken that the primer does not flow onto nor is applied over bituminous or mastic materials.

Coal Tar Pitch emulsion shall not be applied until the primer has cured for 24 hours or until all solvents that may cause bleeding of the emulsion have evaporated. The coal tar pitch emulsion coatings shall not be applied when the weather is foggy or when rain threatens, or when the atmospheric or pavement temperature is below 7 °C (45 °F.).

Due to the settling that may take place in transit, the emulsion shall be thoroughly

agitated by power mixers so that a homogeneous consistency is assured for proper and uniform application.

A total of four applications of emulsion shall be applied to the deck, the fourth coat being in the form of a slurry. The slurry shall be applied at the rate of 1.4 L/m² (0.30 gal. per sq. yd.) in order to obtain 0.5 to 0.6 L (0.13 to 0.15 gal.) of undiluted coal tar emulsion per square meter (square yard). The first three coats of undiluted coal tar emulsion shall be applied at the rate of 0.4 to 0.5 L/m² (0.08 to 0.10 gal. per sq. yd.). Two layers of fiberglass fabric shall be placed parallel to the length of the bridge. The necessary time shall be allowed between coats for proper setting. After the roadway surface has been properly primed and approved by the Engineer, the coal tar pitch emulsion shall be applied according to one of the two following methods:

- (a) Hand Method The emulsion shall be applied in 4 coats in the amounts per square meter (square yard) as required. The undiluted material shall be poured in strips on the pavement and spread with a squeegee or brush, smoothing out with a brush. This procedure shall be continued until the entire area is covered. Application can also be made by means of a heavy spray gun when approved by the Engineer. The first coat shall be allowed to dry or cure sufficiently to prevent pickup before the second coat is applied. When spreading the second coat, it shall be spread crosswise to the placing of the first coat when practicable.
- (b) Distributor or Applicator When applied by distributor or approved type of applicator, the emulsion shall be applied uniformly to the surface of the pavement at the prescribed pressures and in the amount per square meter (square yard) as stated. The emulsion shall be thoroughly mixed before use. When necessary to dilute the emulsion in order to aid proper application, the emulsion may be diluted with a maximum of 10 percent by volume of clean fresh water as directed by the Engineer.

In all cases, the waterproofing shall begin at the low point of the surface to be waterproofed so that water will run over and not against the laps.

One width of the fiberglass fabric shall be laid loosely into the second coat of emulsion while the film is still wet. The fabric shall be brushed into the emulsion thereby eliminating all wrinkles and blisters, but without stretching the fabric tight. The adjoining widths of fabric shall be installed in the same fashion, side lapping the former by 75 mm (3 inches). All end laps shall be at least 300 mm (12 inches). The upper layer of fabric shall be applied in the same manner, but the laps shall extend over the lower laps by at least 150 mm (6 inches).

The fourth coat shall be a slurry top coat. The emulsion and aggregate shall be blended and premixed to produce a slurry top coat. The coal tar emulsion may be diluted up to a ratio by volume of 0.1 parts water to 1 part coal tar pitch, emulsion to facilitate the mixing and spreading of the slurry. The slurry shall contain a nominal 0.5 kg (4 lbs.) of fine aggregate per liter (gallon) of coal tar pitch emulsion.

Before application, the materials shall be proportioned accurately and mixed by suitable mixing equipment. Mixing machines for preparing the slurry may be mortar mixers, concrete mixers, or any type approved by the Engineer capable of producing a uniform mixture of emulsion and aggregate. The emulsion and the water shall be first charged into the mixer and blended into desired consistency, then the aggregate shall be added at a slow and uniform rate while the mixing is continued until the batch

aggregate is incorporated. After all the components are in the mixer, the mixing shall continue for minimum of 5 minutes or as long as may be necessary to produce a smooth, free flowing, homogeneous mixture of a uniform consistency. Mixing shall be continuous from the time the bitumen is placed into the mixer until the slurry is poured into the spreading equipment.

During the entire mixing process, there shall be no breaking, segregating or hardening of the emulsion, nor balling, lumping or swelling of the aggregate. After the required mixing period, the slurry shall be spread over the designated area while the slurry is of the proper consistency. The slurry shall be uniformly spread over the last layer of the fiberglass fabric at the rate of 0.5 to 0.6 L (0.13 to 0.15 gal.) of undiluted coal tar emulsion per square meter (square yard) of surface. The slurry shall be applied at the rate of 1.3 to 1.4 L/m² (0.28 to 0.30 gal. per sq. yd.) in order to obtain 0.5 to 0.6 L (0.13 to 0.15 gal.) of undiluted coal tar emulsion per square meter (square yard).

The application of the slurry shall be either by hand methods using rubber squeegees for spreading or by any other suitable mechanical method approved by the Engineer. The slurry shall be applied at a uniform rate as specified.

A suitable spray type applicator or distributor approved by the Engineer may be used for applying the slurry. Such equipment shall be equipped with an agitator to keep the slurry uniformly mixed before and during application and so designed to uniformly spread the slurry on the roadway at the specified rate of application.

At all times, particular care shall be taken to protect the membrane from damage. Any damage which may occur shall be repaired by patching in a manner satisfactory to the Engineer. The complete membrane shall be allowed to cure for at least 24 hours before placement of the protection layer.

**581.07 Protection Layer.** The fine aggregate and asphalt cement shall be combined in such proportions that the composition by weight of the finished mixture shall be as directed by the Engineer but within the following range limits:

Fine Aggregate 90.0 to 93.0% Bitumen 7.0 to 10.0%

The hot-mix plant used for the manufacture of the protection course material shall be capable of producing completely coated uniform mixtures within the tolerances set forth and at a uniform workable temperature as specified by the Engineer, but not to exceed 175 °C (350 °F.) for the mixture when leaving the plant.

The exact proportions, within the limits specified, shall be regulated so as to produce a satisfactory mixture with all particles coated with asphalt cement. The fine aggregate shall be mixed dry for not less than 15 seconds. The asphalt cement shall then be added in an evenly spread sheet over the full length of the mixer box. The mixing shall be continued for a period of not less than 30 seconds and at least until the aggregate is completely coated with bitumen.

The asphalt sand seal protection layer shall be placed and compacted according to the requirements of Section 406 except that the material shall not be mixed or placed when the atmospheric temperature is below 10  $^{\circ}$ C (50  $^{\circ}$ F.). The temperature of the mix shall not be less than 144  $^{\circ}$ C (290  $^{\circ}$ F.) at time of placement. The mix shall be placed and compacted so as to provide a protection layer of approximately 15 mm (1/2 inch) in thickness.

- **581.08 Sequence of Construction Operations.** The sequence of construction operations for the waterproofing membrane systems shall be as follows:
  - (a) Penetrating Primer 0.05 L/m<sup>2</sup> (0.01 gal./sq. yd.) [Cure 24 Hours]
  - (b) Coal Tar Emulsion 0.4 to 0.5 L/m<sup>2</sup> (0.08 to 0.10 gal./sq. yd.) [Cure 4 Hrs.]
  - (c) Coal Tar Emulsion 0.4 to 0.5 L/m² (0.08 to 0.10 gal./sq. yd.) & Fiberglass Fabric 55 g/m² (1.65 oz./sq. yd.) [Cure 4 Hrs.]
  - (d) Coal Tar Emulsion 0.4 to 0.5 L/m<sup>2</sup> (0.08 to 0.10 gal./sq. yd.) & Fiberglass Fabric 55 g/m<sup>2</sup> (1.65 oz./sq. yd.) [Cure 4 Hrs.]
  - (e) Coal Tar Emulsion Slurry 1.4 L/m<sup>2</sup> (0.3 gal./sq. yd.) incl. (Cure 24 Hrs.)
  - (f) Asphalt Sand Seal Protection Layer 13 mm (1/2 inch) thick

#### 581.09 Method of Measurement.

- (a) Contract Quantities. The requirements for the use of Contract Quantities shall conform to Article 202.07(a).
- (b) Measured Quantities. The waterproofing membrane system, complete in place and accepted, will be measured for payment and the area computed in square meters (square yards) of bridge deck surface covered. No measurement or allowance will be made for laps, material used for extending up curb faces or other vertical barriers, material used for extensions over lips or edges, or for repairs.
- **581.10 Basis of Payment.** This work will be paid for at the contract unit price per square meter (square yard) for WATERPROOFING MEMBRANE SYSTEM.

# SECTION 582. BITUMINOUS CONCRETE SURFACING ON BRIDGE DECKS

**582.01 Description.** This work shall consist of constructing a bituminous concrete surface course on a prepared bridge deck.



**582.02** Compaction Equipment. The breakdown rolling shall be accomplished with a three-wheel or a tandem roller having a unit compression on the drive wheels of not less than 50 nor more than 70 N/mm (300 nor more than 400 lbs. per inch) of roller width. Vibratory rollers will not be permitted on bridge decks.

#### CONSTRUCTION REQUIREMENTS

- **582.03 General.** The work shall be performed, measured and paid for according to the requirements of Section 406, except as specified for obtaining the density.
- **582.04 Target Density.** A target density will be established from tests conducted on a calibration strip consisting of 30 m (100 ft.) of bituminous concrete surface course mixture placement on the bridge deck. The mixture used shall

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conform to the requirements of the approved job-mix formula for the project.

A target count rate which represents maximum compactive effort will be determined with nuclear testing equipment within calibration strip.

Compaction of the strip with the breakdown roller shall commence immediately after the surface course is placed and shall be continuous and uniform over the entire area. All rolling operations must be completed before the temperature of the mixture drops below 90 °C (190 °F.). At a minimum of two random locations within the calibration strip, a growth curve consisting of a plot of counts per minute vs. number of passes with a breakdown roller will be developed.

The growth curve at each random location will be established by using a nuclear gauge using a fast count or with a nuclear gauge using a 30-second timing cycle in the backscatter position. Tests will be made after each pass until the lowest count either raises or remains the same. At this time, mineral filler will be spread and a 4 minute (calibration) count will be taken in the backscatter position to establish the relative target density.

The established average target density shall apply throughout the project unless there are changes in materials in the mix and/or an appreciable change in the job-mix formula. The Engineer may require a new average target density to be established if there is reason to believe that the mixture being placed is not the same as the mixture used to determine the target density.

Unless otherwise provided, the cost of constructing the calibration strip will be considered included in to the cost of the mixture for which a strip is required.

**582.05** Acceptance Tests. Acceptance tests will be performed once the average target density has been established. At least one acceptance test will be taken for each 60 m (200 ft.) or portion thereof of bridge deck per paver pass. Acceptance tests on material placed in a single day shall average 98 percent of the established average target density with no one test being below 95 nor more than 103 percent of the established target density. If the above requirements for average or individual density tests cannot be obtained, placement of additional material will be discontinued until the cause of the failure is investigated and corrected.

Acceptance tests will be performed with the same nuclear equipment used to establish the average target density. Acceptance tests will be for one-minute duration and the area to be tested shall be prepared with mineral filler prior to testing.

#### SECTION 583. PORTLAND CEMENT MORTAR FAIRING COURSE

- **583.01 Description.** This work shall consist of placing portland cement mortar along precast, prestressed concrete bridge deck beams as required for fairing out any unevenness between adjacent deck beams prior to placing of waterproofing membrane and surfacing.
- **583.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 Materials:

		Article/Section
(a)	Portland Cement	1001
(b)	Fine Aggregate	1003.02
(c)	Water	1002
(d)	Epoxy Concrete Adhesvie	1025.01

#### CONSTRUCTION REQUIREMENTS

**583.03 General.** The mixture for portland cement mortar shall consist of 3 parts sand to 1 part portland cement by volume. The amount of water shall be no more than that necessary to produce a workable, plastic mortar.

Prior to placement of the mortar fairing course, all areas where unevenness occurs between the deck beams shall be prepared and coated with an epoxy concrete adhesive as specified in Article 503.09(a)(2).

The mortar shall be placed to the thickness necessary to eliminate unevenness between the beams. It shall be placed to form a smooth even surface from the higher beam edges to the lower surface. The mortar finished surface shall slope not less than 1:3 (V:H) and shall be feathered smoothly into the deck beam surfaces. The finish shall be free of depressions or sharp edges.

The mortar shall be cured for a period of not less than 3 days by the wetted burlap method according to Article 1020.13(a)(3). Curing shall commence as soon as practicable after mortar placement.

- **583.04 Method of Measurement.** Portland cement mortar fairing course will be measured for payment in meters (feet) along the beam edges.
- **583.05** Basis of Payment. This work will be paid for at the contract unit price per meter (foot) for PORTLAND CEMENT MORTAR FAIRING COURSE.

#### SECTION 584, EPOXY GROUTING OF ANCHOR RODS AND BARS

- **584.01 Description.** This work shall consist of drilling and epoxy grouting anchor rods and bars into hardened concrete when specified or when approved by the Engineer.
- **584.02 Materials.** Materials shall meet the requirements of the following Article of Section 1000 Materials:

	Item	Article	/Section
(a)	Epoxy Grout		1025.04

#### CONSTRUCTION REQUIREMENTS

**584.03 General.** Holes shall be drilled in the concrete to 6 mm (1/4 inch) larger in diameter than the diameter of the anchor rods or bars and to the depth shown on the plans. A template or other approved method shall be used to assure accurate location of the drilled holes. All holes shall be blown free of concrete dust and chips and shall be absolutely dry prior to placing the epoxy grout.

Prior to inserting the anchor rod or bar into the hole, the hole shall be filled approximately 1/3 full of the mixed epoxy grout. The anchor rod or bar shall be inserted into the partially filled hole and moved up and down several times to insure total contact of the grout with concrete as well as the rod or bar. Additional grout shall be extruded to proper concrete level and finished as necessary. The anchor rod or bar shall be aligned to maintain a perpendicular plane. No load shall be applied to the anchors until the grout has cured for at least 24 hours.

**584.04** Basis of Payment. The drilling of the holes, furnishing of the epoxy grout and setting of the anchor rods or bars in the epoxy grout will not be measured or paid for separately, but shall be considered as included in the unit price bid for the item of construction involved.

#### SECTION 585. EPOXY MORTAR REPAIR

- **585.01 Description.** This work shall consist of furnishing all materials and labor required to remove deteriorated concrete and replace it with an epoxy mortar at those locations shown on the plans or designated by the Engineer.
- **585.02 Materials.** Materials shall be according to the following Article of Section 1000 Materials:

	Ite	m Article	e/Section
(a)	<b>Epoxy Mortar</b>		1025.02

#### CONSTRUCTION REQUIREMENTS

**585.03 General.** The areas to be patched shall have all loose, unsound concrete removed and then cleaned by sandblasting, vacuumed and/or blown clean with oil-free compressed air. The sound concrete remaining shall then be scrubbed with an epoxy-resin prime just prior to the placement of the epoxy mortar.

The epoxy mortar shall be mixed and placed according to the manufacturer's printed instructions. Such instructions shall be supplied to the Contractor by the supplier of the epoxy system.

The mortar shall be placed and finished to the contours of the member as originally constructed.

- **585.04 Method of Measurement.** Epoxy mortar repair will be measured for payment in place and the volume computed in liters (cubic feet).
- **585.05 Basis of Payment.** This work will be paid for at the contract unit price per liter (cubic foot) for EPOXY MORTAR REPAIR.

#### SECTION 586. SAND BACKFILL FOR VAULTED ABUTMENTS

**586.01 Description.** This work shall consist of furnishing, transporting and placing a sand backfill behind vaulted abutment mainwalls to serve as a form for the placement of the concrete approach slab.

**586.02 Materials.** Materials shall conform to the following Article of Section 1000 - Materials:

Note 1. The material for backfilling shall be a bank-run or stockpiled sand.

#### CONSTRUCTION REQUIREMENTS

**586.03 General.** The wedge behind the abutments shall be backfilled with the sand material to the required elevation of the bottom of the approach span slabs. The backfill shall be placed in convenient lifts for the full width between the abutment sidewall. Mechanical compaction will not be required. Backfilling shall not be started until test specimens show that the concrete in the abutment has attained a flexural strength of 4,500 kPa (650 psi) but in no case until at least 7 days have elapsed after the placing of the concrete. In the absence of tests to determine the flexural strength, the sand backfill shall not be placed until at least 14 days have elapsed after the placing of the concrete, exclusive of days on which the temperature of the air surrounding the concrete falls below 7 °C (45 °F.).

The sand backfill shall be brought to the finished grade of the bottom of the abutment approach slab to serve as a base for placement of the slab. The Contractor, subject to approval of the Engineer, may prepare the top surface of the fill to receive the concrete as he/she deems necessary for satisfactory placement, except no additional compensation will be allowed for the method used.

#### 586.04 Method of Measurement.

- (a) Contract Quantities. The requirements for the use of Contract Quantities shall conform to Article 202.07(a).
- (b) Measured Quantities. Sand backfill will be measured for payment in place, and the volume computed in cubic meters (cubic yards). The volume shall be determined by measuring the wedge areas above the embankment slope, behind the abutment mainwalls, and for the full width between sidewalls.
- **586.05** Basis of Payment. This work will be paid for at the contract unit price per cubic meter (cubic yard) for SAND BACKFILL.

#### SECTION 587. BRIDGE SEAT SEALER

- **587.01 Description.** This work shall consist of furnishing the required materials, cleaning bridge seats, and applying a sealer to the bridge seats of piers and/or abutments as described and all incidental and collateral work as required to perform the work as directed by the Engineer.
- **587.02 Materials.** Materials shall meet the requirements of the following Article of Section 1000 Materials:

	Item	Article/Se	ection
(a)	Bridge Seat Sealer		1026

#### CONSTRUCTION REQUIREMENTS

**587.03 General.** Before the sealer is applied, the bridge seats shall be cleaned with high pressure air blast or wire brushes to remove all oil, grime, and loose particles to clean, bare concrete. Surfaces that will not respond to cleaning by air blast or wire brushes shall, if required by the Engineer, be cleaned by sandblasting.

Extreme care shall be taken to prevent the sealer from flowing over the edges and onto the sides of the abutments or piers.

The sealer shall be applied according to the manufacturers' instructions.

**587.04 Basis of Payment.** This work will be paid for at the contract unit price per square meter (square foot) for BRIDGE SEAT SEALER.

#### **SECTION 588. CONCRETE JOINT SEALER**

- **588.01 Description.** This work shall consist of furnishing all the required materials, and the placement of a concrete joint sealer of a two-component, cold-applied, elastomeric, polymer type and a rod of polychloroprene, rubber or any other approved material, to seal the horizontal joint in the bridge roadway slab.
- **588.02 Materials.** Materials shall meet the requirements of the following Article of Section 1000 Materials:

# **CONSTRUCTION REQUIREMENTS**

**588.03 General.** The faces of all joints to be sealed shall be free of all foreign matter, curing compound, oils, grease, dirt, free water, and laitance. Concrete joints to be sealed shall be free of cracked or spalled areas. Any cracked areas shall be chipped back to sound concrete before placing joint sealer.

The concrete joint sealant shall be applied only when the ambient temperature is 20  $^{\circ}$ C (68  $^{\circ}$ F.) and rising.

A continuous length of rod of the size designated on the plans, shall be placed in the joint opening at the depth below the finished surface of the joint shown on the plans. The surface of the rod shall be wiped clean with solvent (toluene or xylol) before installation.

All sealing compound shall be placed with an applicator recommended by the manufacturer, and the mixing and placing instructions of the manufacturer shall be adhered to. A copy of these directions and the specifications for the applicator to be used shall be filed with the Bureau of Materials and Physical Research.

No sealing compound shall be placed in a joint on any material (joint filler or expansion board) containing any bituminous material until a separating barrier of foil or other suitable material has been placed on top of bituminous material in such a manner so that the sealing compound cannot contact the bituminous material.

No material that will allow bitumen to soak through may be used. When it is deemed necessary to prevent bonding of the sealing compound to a joint surface, the Engineer may require the Contractor to place, at no extra cost, paper, plastic, or foil barriers over the joint surface before applying the sealing compound.

The joint must be covered with a masking tape before the application of the protective coat on the bridge deck to prevent the spray from filming the vertical faces.

All bridge joints shall be filled to 6 mm (1/4 inch) below the finished surface of the joint. This is to be interpreted to mean that the surface of the sealant shall be level and the point of its contact with the sidewalls of the joint shall be 6 mm (1/4 inch) below the finished surface of the joint.

Any sealing compound that is not bonded to the joint wall or face twenty-four hours after placing shall be removed and the joint shall be cleaned and resealed at the Contractor's expense.

**588.04** Basis of Payment. Furnishing and placing the closure rod and polymer compound joint sealer, will not be paid for as a separate item, but shall be considered as included in the unit price bid for the major item of construction involved, and no additional compensation will be allowed.

#### SECTION 589. ELASTIC JOINT SEALER

- **589.01 Description.** This work shall consist of furnishing and placing an elastic sealer in joints of bituminous concrete surface course on bridge decks according to the details shown on the plans and as directed by the Engineer.
- **589.02 Materials.** Materials shall meet the requirements of the following Article of Section 1000 Materials:

	Item	Article/Se	ection
(a)	Elastic Joint Sealer		1059

#### **CONSTRUCTION REQUIREMENTS**

**589.03 General.** Prior to sealing, the joint shall be sawed to form a reservoir for the sealing material. The sawed joint shall be 5 mm (1/4 inch) wide and 20 mm (3/4 inch) deep. Immediately prior to pouring the elastic sealer, the joint shall be cleaned with compressed air and shall be free of foreign and loose material and in a dry condition. The joint shall not be poured when the temperature is below 4 °C (40 °F.) or when the weather is foggy or rainy.

The equipment required for this work shall be approved by the Engineer before the work will be permitted to start. The heating apparatus and equipment for applying the sealing material shall meet the recommendations of the manufacturer supplying the sealing material, and shall be such that the joint will be completely filled from bottom to top to the satisfaction of the Engineer.

Sufficient compound shall be placed in the joints so that the top of the seal is flush with the top surface of the wearing course.

**589.04** Basis of Payment. Sawing and cleaning the joint, and furnishing and placing the sealer, will not be paid for as a separate item, but shall be considered as included in the unit price bid for the item of bituminous concrete surface course involved, and no additional compensation will be allowed.

#### SECTION 590. EPOXY CRACK SEALING

- **590.01 Description.** This work shall consist of furnishing of all labor and material required to seal cracks in structural concrete with an epoxy bonding compound as shown on the plans and as directed by the Engineer.
- **590.02 Materials.** Materials shall meet the requirements of the following Article of Section 1000 Materials:

	Item	Article	/Section
(a)	<b>Epoxy Bonding Compound</b>		1025.03

#### CONSTRUCTION REQUIREMENTS

**590.03 General.** The areas designated for epoxy crack seal repair shall be prepared for sealing by removing all dust, debris, or disintegrated material from the crack by the use of oil-free compressed air and/or vacuuming. Any cracks holding oil or grease must be chipped out to clean concrete.

Horizontal cracks shall be grouted by pouring mixed material into the clean, "vee'd" out cracks. Vertical cracks shall be grouted by installing suitable pipe nipples, zerk or alemite fittings, or polyethylene one-way valves every 300 to 900 mm (1 to 3 ft.) as required, depending on width of crack. Surface of cracks between nipples or fittings shall be sealed with a suitable sealing compound recommended by the supplier of the bonding compound. When the sealing compound is hard, a standard caulking gun or other suitable pressure gun shall be used to pump the compound into the cracks, starting at the lowest nipples or fittings and progressing upward until all cracks are grouted. When the grout is cured, the fittings shall be removed and the surface smoothed by stoning or grinding.

- **590.04 Method of Measurement.** Epoxy Crack Sealing will be measured in for payment in meters (feet), complete in place.
- **590.05 Basis of Payment.** This work will be paid for at the contract unit price per meter (foot) for EPOXY CRACK SEALING.

#### SECTION 591. GEOCOMPOSITE WALL DRAIN

- **591.01 Description.** This work shall consist of furnishing and installing geocomposite wall drain on the soil side of abutment walls, wing walls, retaining walls and culvert sidewalls.
- **591.02 Materials.** Materials shall meet the requirements of the following Article of Section 1000 Materials:

	Item	Article	Section
(a)	Geocomposite Wall Drain		1040.21

#### CONSTRUCTION REQUIREMENTS

**591.03 General.** Geocomposite wall drain shall be constructed in horizontal courses with the first course resting on the top of the footing. The geocomposite shall be in intimate contact with the wall and secured with concrete nails not less than 50 mm (2 inches) long with approved washers not less than 5800 mm<sup>2</sup> (9 sq. inches) in area. The spacing of the concrete nails shall be as directed by the Engineer but shall not be more than 1 m (3 ft.) apart, both horizontally and vertically. There shall be at least one horizontal row of nails in each course.

Horizontal seams shall be formed by a 100-mm (4-inch) flap of geotextile extending from the upper course and lapping over the top of the lower course or by a 300-mm (12-inch) wide continuous strip of geotextile centered over the seam and securely fastened to the upper course with continuous 75-mm (3-inch) wide plastic tape. The overlapping flap or strip shall be fastened to the lower course intermittently as directed by the Engineer, but the spacing shall not exceed 600 mm (2 ft.). Vertical splices shall be formed by a 100-mm (4-inch) flap of geotextile extending from one or the other abutting pieces or by a 300-mm (12-inch) wide continuous strip of geotextile centered over the splice. Vertical splice flaps or strips shall be continuously fastened to the geocomposite with continuous applications of contact adhesive or 75-mm (3-inch) wide plastic tape.

The bottom, side and top edges of the geocomposite shall be covered with a suitable cap formed by folding a 150-mm (6-inch) flap or a 300-mm (12-inch) wide strip of geotextile over the edge and securing it in place with a continuous application of contact adhesive or 75-mm (3-inch) wide plastic tape. All seams, splices, bottom caps, top caps and end caps shall be constructed so that backfill material cannot enter the geocomposite during or after construction.

Connection to pipe outlet systems shall be as shown on the plans. Outlet fittings shall be fastened to the wall drains as directed by the manufacturer and so that backfill materials cannot enter the system during or after construction. If necessary, to facilitate the rapid and complete flow of water from the wall drain into the pipe outlet, a portion of the wall drain core equal to the cross section at the outlet shall be removed. Weep holes shall be accommodated by cutting a matching hole through the wall drain. An approved weep hole cover extending at least 100 mm (4 inches) from the edge(s) of the hole shall be securely fastened to the soil side of the wall drain by 75 mm (3 inch) wide plastic tape or contact adhesive applied continuously around its periphery.

- **591.04 Method of Measurement.** Geocomposite wall drain will be measured for payment in place in square meters (square yards) of actual surface area covered.
- **591.05 Basis of Payment.** This work will be paid for at the contract unit price per square meter (square yard) for GEOCOMPOSITE WALL DRAIN.

# **SECTION 592. BRIDGE WASHING**

**592.01 Description.** This work consists of the removal of all accumulated foreign material from the entire bridge, including bridge deck, sidewalk, curbs, pier

and abutment caps, all superstructure members, trusses, interior of truss members, flanges and webs of beams or girders, washing of expansion joints and drains, to prevent deterioration of the structure.

**592.02 Equipment.** Washing equipment shall consist of power brooms, air compressors, water tanks, water pumps with associated delivery hardware, and hand tools, to properly flush, clean, and remove all foreign material from the bridge structure. Other types of washing equipment may be used, subject to approval of the Engineer. Water pressure shall be sufficient to remove the accumulated material without damaging paint coverage of the structural steel.

Other equipment such as hi-reach trucks, and under-bridge-access units may be necessary to gain access to areas designated for washing. It will be the Contractor's responsibility to determine and utilize whatever method and equipment best suits his/her operation to successfully wash the structures. This equipment shall be available to the inspector until final acceptance of the work.

#### **CONSTRUCTION REQUIREMENTS**

**592.03 General.** All accumulated foreign material shall be removed from the bridge. Special care shall be taken on connected parts, members below open joints and difficult to reach areas to remove all foreign material.

All deck drains shall be flushed with water under pressure. Blockages in the deck drains shall be removed so that they will drain properly. The drain system may have to be taken apart to remove large blockages. Should they be taken apart, they shall be returned to their original configuration immediately after washing. Foreign material in the scuppers at the drains shall be either removed externally or flushed down the drain system. The area beneath all expansion devices shall be thoroughly flushed and washed with water under pressure. These areas include drain troughs beneath the expansion device and pier tops immediately adjacent to the expansion device. All abutment and bridge seats shall have foreign material removed by compressed air, water under pressure, or hand sweeping. All structural steel and bearings shall be washed with water under pressure. All foreign debris shall be removed from truss members. All foreign material accumulated in the interior of members shall be removed. Areas which have been washed shall be free of all accumulate sand, gravel, dirt, bird nests and excrete, and other foreign materials. Free standing water shall be removed upon completion of washing.

The Contractor shall provide adequate protection against worker inhalation of dust from his/her washing operations.

The Contractor shall exercise due caution while washing those portions of the structures that are adjacent to or above parking lots, buildings, sidewalks, roadways, and railroad tracks. Dirt and debris deposited on adjacent property or redeposited on the bridge shall be removed to the satisfaction of the Engineer at the Contractor's expense.

The Contractor shall obtain his/her own source of water. The water shall be according to Section 1002. Any expense involved in securing the proper water shall be borne by the Contractor.

**592.04 Traffic Control.** The road shall be kept open to traffic according to the requirements of Article 701.05(d)(4).

- **592.05 Method of Measurement.** Bridge washing will be measured for payment in units of each at the locations specified.
- **592.06** Basis of Payment. This work will be paid for at the contract unit price each for BRIDGE WASHING at the location specified.

# SECTION 600. INCIDENTAL CONSTRUCTION DRAINAGE RELATED ITEMS

# SECTION 601. PIPE DRAINS, UNDERDRAINS AND FRENCH DRAINS

**601.01 Description.** This work shall consist of constructing pipe drains and pipe underdrains of the required inside diameter, and constructing french drains consisting of trenches filled with aggregate.

Pipe underdrains in backslopes shall be designated as follows:

Depth of Installation

<u>Bopur of motanation</u>	<u> 1                                   </u>
1.2 m (4') or less	Backslope Drains, Type 1
Greater than 1.2 m (4') not exceeding 2.4 m (8')	Backslope Drains, Type 2
Greater than 2.4 m (8') not exceeding 3.6 m (12')	Backslope Drains, Type 3

Type

**601.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 - Materials:

Item	Article/Section
(a) Drain Tile	1040.01
(b) Extra Strength Clay Pipe (Note 4)	1040.02
(c) Extra Strength Perforated Clay Pipe	
(d) *Corrugated Steel Culvert Pipe (Note 1)	
(e) Perforated Corrugated Steel Pipe (Note 1)	
(f) *Bituminous Coated Corrugated Steel Culvert Pipe (Note 1)	1006.01
(g) *Corrugated Aluminum Alloy Culvert Pipe (Note 1)	
(h) Perforated Corrugated Aluminum Alloy Pipe (Note 1)	1006.03
(i) *Bituminous Coated Corrugated Aluminum Alloy	
Culvert Pipe (Note 1)	
(j) Concrete Drain Tile	
(k) *Concrete Sewer, Storm Drain and Culvert Pipe, Class 3	
(I) Perforated Polyvinyl Chloride (PVC) Pipe	
(m) *Polyvinyl Chloride (PVC) Pipe	
(n) Perforated Corrugated Polyethylene (PE) Tubing (Note 2)	
(o) *Corrugated Polyethylene (PE) Tubing (Note 2)	1040.12
(p) Perforated Corrugated Polyvinyl Chloride	101011
(PVC) Pipe With A Smooth Interior	1040.14
(q) *Corrugated Polyvinyl Chloride (PVC) Pipe With	4040.45
A Smooth Interior (Note 4)	
(r) Drainage Mat Underdrain (Note 3)	1040.13
(s) Perforated Corrugated Polyethylene (PE) Pipe with a	1040 17
Smooth Interior(t) *Corrugated Polethylene (PE) Pipe with a	1040.17
Smooth Interior (Note 4)	1040.20
(u) Sand Backfill for Underdrains and Bedding	
(v) Aggregate for French Drains	
(w) Geotechnical Fabric for French Drains	
(w) Ocolooninical Labric for French Diality	1000.03

\*Pipe Drains are limited to this type material and this material will not be

permitted for Pipe Underdrains.

- Note 1. The thickness for steel and aluminum pipe of various sizes shall be that shown in Article 542.03, Tables 1B and 1C, for pipe having up to 900 mm (3 ft.) of cover over the top of the pipe.
- Note 2. This material is limited to 100-mm (4-inch) diameter pipe when used for pipe underdrains or pipe drains.
- Note 3. This material will be permitted when pipe underdrains 100 mm (4 inch) is specified.
- Note 4. This material shall be used for pipe underdrains (special).

No open joint pipe will be allowed for pipe underdrains used under or along the edge of pavement or shoulders and for pipe drain outlets.



Perforated corrugated polyethylene (PE) tubing and perforated corrugated polyethylene (PE) pipe with a smooth interior shall be encased in a fabric envelope weighing not less than 120 g/m $^2$  (3.5 oz. per sq. yd.) and conforming to Article 1080.01.

The Contractor may be permitted to substitute a stronger tile or pipe of the same kind of material for any tile or pipe as listed above. No extra compensation will be allowed for such substitution.

When metric pipe sizes are specified the next larger manufactured size may be substituted at no extra cost to the Department.

## **CONSTRUCTION REQUIREMENTS**

**601.03 Pipe Drain Installation.** Pipe Drains shall be installed at the locations shown on the plans or as directed by the Engineer. The pipe shall be bedded in the underlying material to a depth not less than 10 percent of the external diameter of the pipe and, where trenching is required, the trench shall have a width of not less than the external diameter of the pipe plus 450 mm (18 inches). The bottom of the trench shall be compacted in a manner meeting the approval of the Engineer.

Joints and fittings may be assembled without gaskets or solvent cement if the joint is hand tight and the spigot enters the socket not less than 1/3 of the socket depth for solvent cement joints and full-depth for elastomeric gasket joints.

No pipe shall be placed in the trench until it and the prepared foundation have been approved by the Engineer. The pipe shall be laid so that the flow line will be at the grade shown on the plans or established by the Engineer. The permissible minimum cover over a pipe shall be 150 mm (6 inches).

Laying of pipes shall commence at the outlet end and proceed toward the inlet end with the pipes true to line and grade.

The ends of the pipe shall be carefully cleaned before they are placed, and shall be placed to avoid unnecessary handling on the foundation. As each length of pipe is laid, the ends of the pipe shall be protected to prevent the entrance of any material.

Longitudinal laps shall be placed at the sides and separate sections of pipe shall

be joined with tightly drawn, approved connecting bands.

The trench shall be backfilled with select material, meeting the approval of the Engineer, placed in 200-mm (8-inch) layers, loose measurement, and compacted to the Engineer's satisfaction.

Material excavated from the trench, if it meets the approval of the Engineer, may be used for backfill.

# 601.04 Pipe Underdrain Installation.

(a) General. Pipe underdrains placed along pavement edges shall be outletted across the shoulder to the ditch approximately every 150 m (500 ft.) and at all low points in the flow line of the underdrain. Pipe underdrains may be outletted into the cross road culvert when the fill above the culvert is 1.5 m (5 ft.) or less. Pipe underdrains shall be outletted using Pipe Underdrain (Special) according to the details shown on the plans.

When pipe underdrains are included in contracts involving pavement patching, the pipe underdrains shall be installed after patching operations.

When installing pipe underdrains on contracts with existing shoulders and it is determined by the Engineer that the Contractor's equipment or method of excavation is causing the material under the pavement to become dislodged, the Contractor shall move the location of the trench laterally away from the pavement a sufficient distance so that edge sluffing will not occur under the pavement. No additional compensation will be allowed the Contractor for any increases in cost or quantities of backfill material that may be caused by a change in the location of the pipe underdrain trench.

On contracts where existing shoulders are to be resurfaced, the trench of the pipe underdrain and pipe underdrain (special) shall be backfilled with FA1 or FA2 to within 125 mm (5 inches) of the surface of the existing shoulder. The top 125 mm (5 inches) of the trench shall be backfilled with a bituminous aggregate mixture meeting the requirements of Section 482 and compacted to a density of not less than 90 percent of the theoretical density.

On contracts where the existing shoulders are not being resurfaced, the trench of the pipe underdrain and pipe underdrain (special) shall be backfilled with FA 1 or FA 2 to within 200 mm (8 inches) of the surface of the existing shoulder. The top 200 mm (8 inches) of the trench shall be backfilled with a bituminous aggregate mixture meeting the requirements of Section 482 and compacted to a density of not less than 90 percent of the theoretical density.

Perforated pipe shall be placed with the perforations down and the pipe sections shall be joined securely with the appropriate coupling fittings or bands.

Non-perforated pipe with bell ends shall be laid with the bell end upgrade and with open joints wrapped with suitable material to permit entry of water or unwrapped as specified. Upgrade ends of all pipe installations shall be closed with suitable plugs to prevent entry of soil materials.

# Art. 601.04 Pipe Drains, Underdrains and French Drains

No equipment shall be operated directly upon the completed pipe installation for longitudinal underdrains constructed along the edges of pavement or subbase.

(b) Perforated Corrugated Polyethylene (PE) Tubing. Trenches shall be excavated to the dimensions and grades required by the plans or as directed by the Engineer. In no case, shall the diameter of the 180° semicircular bedding groove exceed the outside diameter of the plastic tubing and fabric envelope by more than 6 mm (1/4 inch) and in no case, shall the width of trench exceed 250 mm (10 inches). The trench bottom outside the limits of the bedding groove shall be undisturbed and free of loose material.

The excavation of the trench and 180° semicircular bedding groove and the placement of the underdrain tubing shall be accomplished in a single continuous operation. The underdrain tubing shall be laid true to grade and shall not be stretched more than 5% during installation. The underdrain tubing shall be seated in the bedding groove and held firmly in place by mechanical means while sand backfill is placed and compacted to a height of 125 mm (5 inches)  $\pm$  25 mm (1 inch) above the tubing. After the first lift is compacted, the remainder of the sand backfill shall be placed and compacted. Placement and compaction of the remainder of the backfill may be included in the same pass as the excavation of the trench and bedding groove and the placement of the tubing. When approved by the Engineer, placement and compaction of the 2 lifts of backfill may be accomplished in a separate operation closely following the trenching and tubing placement. The maximum distance between the 2 operations shall be the greater of 150 m (500 ft.) or the distance trenched in 15 minutes. The distance shall be further limited as necessary to assure the tubing remains firmly seated in the bedding groove with no loose material from the trenching or other operation under or alongside the tubing. Sloughing of the trench wall shall be prevented. The minimum density of the compacted backfill shall be 90% of the standard laboratory density determined in accordance with AASHTO T 99 (Method A).

(c) Drainage Mat Underdrain. When drainage mat underdrain is being installed in lieu of 100-mm (4-inch) diameter underdrain, trench shall be excavated to the dimensions and grade required by the plans or as directed by the Engineer.

Drainage mat underdrain shall be placed against the shoulder side of the trench without damaging the core or tearing the fabric and held firmly in place while FA1 or FA2 is placed and compacted to a height of 150 mm (6 inches)  $\pm$  25 mm (1 inch). After the first lift is compacted by a vibratory wheel or plate compactor with a rated impact force of approximately 22 kN (5000 lbs.), the remainder of the backfill shall be placed and compacted by a vibratory compactor to the satisfaction of the Engineer.

Each length of drainage mat underdrain shall be joined to the adjacent length prior to installation. Splices shall keep the adjoining mats in proper alignment, not separate during installation, have the same or better compressive strength than the mat and be sealed against infiltration of

backfill material.

(d) Pipe Underdrains Other Than PE Tubing and Drainage Mat. When the pipe for the underdrain is other than corrugated polyethylene (PE) tubing or drainage mat underdrain, the trenches shall be excavated to the dimensions and grade shown on the plans or as directed by the Engineer, and a 25-mm (1-inch) layer of bedding material shall be placed and compacted in the bottom of the trench extending upward under the haunches to 1/2 the depth of the pipe underdrain for the full width and length of trench.

The pipe being used for the pipe underdrain shall be embedded firmly in the bedding material.

After the pipe installation has been inspected and approved, granular backfill shall be placed and compacted to a height of 300 mm (12 inches) above the top of pipe. Displacement of the pipe or the covering at open joints shall be prevented. The remainder of the granular backfill material shall then be placed and compacted to the required height. Any remaining portion of the trench above the granular backfill shall be filled with granular or impervious material as specified and thoroughly compacted.

(e) Pipe Underdrains (Special). Pipe underdrain (special) used for outletting pipe underdrains shall conform to the trench requirements for pipe underdrains.

The portion of the pipe underdrain (special) under the paved shoulder shall be backfilled with sand as specified for pipe underdrains. The remaining portion shall be backfilled with select material meeting the approval of the Engineer.



**601.05** Concrete Headwalls. Concrete headwalls for pipe drains, pipe underdrains (special) and backslope drains shall be constructed at the locations and according to the details shown on the plans. The headwalls shall be either cast-in-place of Class SI Concrete according to the applicable requirements of Section 503, or shall be precast of Class PC Concrete [ 28 MPa (4000 psi) after 28 days] according to the applicable requirements of Section 504. If a precast unit is used, the pipe shall be grouted and sealed to the headwall opening with a cement mortar.

The headwalls shall be placed so that there is a 6 percent minimum slope on the invert. The uppermost point of the headwall shall be placed flush with the roadway slope. The earth side slopes adjacent to the headwall shall then be shaped to conform to the sides and toe of the headwall.

The outlet end of the pipe shall be protected by a permanent rodent shield, upon placement of the pipe drain, pipe underdrain (special) or backslope drain.



The rodent shield shall have the configuration shown on the plans and shall be constructed from hot dip galvanized steel industrial wire cloth 75 mm x 75 mm (#3) mesh 1.6 mm x 1.6 mm (.063" x .063") wire size. The cloth size shall be 125 mm x 175 mm (5" x 7") minimum before fabrication of shield for 100-mm (4-inch) pipe. Other submitted designs for a removable rodent shield may be used with the approval

of the Engineer.

**601.06** French Drains. French drains shall be constructed at the locations and to the dimensions shown on plans or as directed by the Engineer.

The trench shall be excavated to the required width and depth, leveled, and smoothed to the satisfaction of the Engineer prior to filling with aggregate. The specified gradation of fine or coarse aggregate shall then be placed to the required depth and covered with the next specified layer of material.

When the use of geotechnical fabric is specified for lining the trench, the fabric shall be delivered to the jobsite in such a manner to facilitate handling and incorporation into the work without damage. In no case shall the fabric be stored and exposed to direct sunlight that might significantly diminish its strength or toughness. Torn or punctured fabric shall not be used.

After the trench has been approved by the Engineer, the fabric shall be loosely rolled out so the center of the fabric is at the centerline of the excavated trench, and it will not tear when the aggregate is placed. When more than one section of fabric is used, the fabric shall overlap a minimum of 600 mm (2 ft.). Enough fabric shall remain uncovered after the trench is filled to provide for fabric overlap at the top.

During backfilling with angular aggregates, a minimum 150-mm (6-inch) cushion of the aggregate shall be carefully placed over the lined trench before end dumping larger aggregates out of trucks or other equipment. Following the backfilling operation, the fabric shall be lapped over the top and covered with the next specified material.

**601.07 Method of Measurement.** Pipe drains, pipe underdrains, pipe underdrains (special) and backslope drains will be measured for payment in meters (feet), in place. The measured quantities of drainage mat underdrain will be included in the measured quantities of Pipe Underdrain, 100 mm (4 inch).

Measurement for pipe underdrain (special) will be made from the back of the headwall to the centerline of the longitudinal pipe underdrain. At any location where, due to the type of longitudinal pipe underdrain material being used, more than one pipe underdrain (special) is required, only one run of pipe underdrain (special) will be measured for payment.

Aggregate used for french drains will be measured for payment in metric tons (tons) or in cubic meters (cubic yards) according to the requirements of Article 311.08.

Geotechnical fabric for french drains will be measured for payment in place and the area computed in square meters (square yards). The additional fabric required for overlaps of individual sheets and overlaps at the top of the french drain will not be measured for payment.

When pipe underdrains are included on contracts with existing paved shoulders, shoulder removal and replacement over the trench area, as specified in Article 601.04 (a) will be measured for payment in place in meters (feet) along the pipe underdrain and the portion of the pipe underdrain (special) that is under the paved shoulder.

**601.08** Basis of Payment. Pipe drains, underdrains, and backslope drains will be paid for at the contract unit price per meter (foot) for PIPE DRAINS; PIPE

UNDERDRAINS; PIPE UNDERDRAINS (SPECIAL); BACKSLOPE DRAINS, TYPE 1; BACKSLOPE DRAINS, TYPE 2; or BACKSLOPE DRAINS, TYPE 3; of the diameter specified, or of the kind of material and diameter specified.

Concrete headwalls for pipe drains, pipe underdrains (special) and backslope drains will be paid for at the contract unit price each for CONCRETE HEADWALLS FOR PIPE DRAINS.

When pipe underdrains are installed through existing paved shoulders, removing and replacing the existing paved shoulder will be paid for at the contract unit price per meter (foot) for SHOULDER REMOVAL AND REPLACEMENT, of the thickness specified, which price shall include furnishing, placing and compacting the bituminous aggregate mixture.

French drains will be paid for at the contract unit price per metric ton (ton) or cubic meter (cubic yard) for FRENCH DRAINS, which price shall include furnishing and placing the required backfill material, all excavation except rock and that required for the removal of unstable or unsuitable material, and for disposing of surplus materials excavated from the trench.

Geotechnical fabric, when required for french drains, will be paid for at the contract unit price per square meter (square yard) for GEOTECHNICAL FABRIC FOR FRENCH DRAINS.

Removal and replacement of unstable or unsuitable material will be paid for according to Article 109.04.

Excavation in rock will be paid for according to Section 502 for Rock Excavation for Structures.

# SECTION 602. CATCH BASIN, MANHOLE, INLET, DRAINAGE STRUCTURES AND VALVE VAULT CONSTRUCTION, ADJUSTMENT AND RECONSTRUCTION

**602.01 Description.** This work shall consist of constructing, adjusting, or reconstructing catch basins, manholes, inlets, or valve vaults, with frames and grates or lids, and constructing drainage structures with frames and grates.

**602.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 - Materials:

	Item	Article/Section
(a)	Portland Cement Concrete	1020
(b)	Brick	1041
(c)	Concrete Masonry Units	1042
	Gray Iron Castings	
(e)	Precast Reinforced Concrete Manhole Sections	1043
	Ductile Iron Castings	
	Structural Steel	

#### Art 602 02

(h)	External Sealing Band	1057
(i)	Mastic Joint Sealer	1056
(i)	Reinforcement Bars and Fabric	06.10

Note: Inlet and outlet tile or pipe shall be of the same size and kind, and shall meet the same requirements as the tile or pipe with which they are connected.

**602.03 Classification.** Classification as to adjustment or reconstruction shall be on the following basis:

- (a) Adjustment. This classification shall include all those existing catch basins, manholes, inlets and valve vaults which are to be adjusted to grade where 600 mm (2 ft.) or less of masonry will be either added, removed or rebuilt to bring the specified casting to the finished grade of the proposed improvement.
- (b) Reconstruction. This classification shall include all those existing catch basins, manholes, inlets and valve vaults which must be reconstructed or which are to be adjusted to grade where more than 600 mm (2 ft.) of masonry will be either added, removed, or rebuilt to bring the specified casting to the finished grade of the proposed improvement.

#### CONSTRUCTION REQUIREMENTS

**602.04 Concrete.** Cast-in-place concrete shall be constructed of Class SI Concrete according to the applicable portions of Section 503. Precast concrete units shall be constructed of Class PC Concrete according to the applicable portions of Section 504, except shop drawings will not be required.

Mortar shall be composed of one part masonry cement to three parts sand, by volume, based on dry materials. Mortar which has been mixed longer than 30 minutes or which has developed its initial set shall not be used.

Bottom concrete slabs shall be reinforced by either reinforcement bars or welded wire fabric. The minimum reinforcement shall be 975 mm<sup>2</sup>/m (0.46 sq. inch per ft.) in both directions.

- **602.05 Brick Masonry.** Brick masonry shall be constructed in horizontal courses with a running bond using a header course every sixth course, or any standard bond of equivalent strength. The brick shall be laid in mortar.
- **602.06 Concrete Masonry Units.** Concrete masonry units shall be constructed in horizontal courses with vertical joints broken. The units shall be laid in mortar.
- **602.07 Precast Reinforced Concrete Sections.** Precast reinforced concrete sections shall be constructed in horizontal courses. The units shall be laid in mortar, sealed with external sealing bands, or sealed using mastic joint sealer. When mastic joint sealer is used, the material shall completely fill the joint after the units have been brought together. All precast units shall be installed on a 75-mm (3-inch) thick sand cushion of FA1 or FA2 conforming to Article 1003.01.

Art. 602.08



**602.08 Steps.** Steps, when required, shall be of cast gray iron conforming to the contract. Steps shall be embedded into the wall a minimum of 75 mm (3 inches) but shall not be extended on the outside of the structure. Steps of other design and material that conform to the minimum requirements shown on the plans may be used when approved by the Engineer.

**602.09 Wooden Baffles.** Wooden baffles, when required for drainage structures, shall be constructed of pine, fir, spruce, larch, or cedar No. 4 common board (utility), S4S, untreated.

# 602.10 Furnishing and Placing Castings.

- (a) Furnishing. When specified, new castings, including frames, grates and lids, shall conform to Article 604.03.
- (b) Placing for Rigid Pavements. Castings placed on concrete or masonry surfaces shall be set in full mortar beds. Castings shall be set to the finished pavement elevation so no subsequent adjustment will be necessary.
  - Lifting devices will be approved by the Engineer.
- (c) Placing for Flexible Pavements. The structures shall be constructed or adjusted to an elevation which will match the cross section of the subgrade.

After the base course and binder course have been placed, and prior to placing the surface course where there is no binder course, the structures shall be adjusted to grade by removing the binder and base course adjacent to and for a distance not exceeding 300 mm (12 inches) outside the base of the castings. After the structures have been adjusted, the castings shall be set in full mortar beds. Castings shall be set to the finished pavement elevation so that no subsequent adjustment will be necessary, and the space around the casting shall be filled with Class SI Concrete, or a bituminous concrete surface or binder course material to the elevation of the surface of the base course or binder course. If Class SI Concrete is used, it shall be cured for a period of 72 hours. If surface or binder course material is used, it shall be placed in 75-mm (3-inch) layers at the temperature requirements for the placing of surface or binder course and compacted with a pneumatic tamper.

**602.11 Excavation and Backfilling.** In order to permit the joints to be mortared properly and to permit proper compaction of the backfill material, the excavation shall be made to a diameter of at least 150 mm (6 inches) greater than the diameter of the structure.

The space between the sides of the excavation and the outer surfaces of the catch basin, manhole, inlet or valve vault shall be backfilled with sand or stone screenings, when these structures are in the subgrade or if the nearest point of the excavation for these structures falls within 600 mm (2 ft.) of the pavement edge. When the structure falls beyond these limits, other backfilling material may be used with the approval of the Engineer.

Art. 602.12

The backfill shall be compacted as provided in Article 550.07.

- **602.12 Inlet and Outlet Pipes.** Pipe or tile placed in the masonry for inlet or outlet connections shall extend through the walls and beyond the outside surfaces of the walls a sufficient distance to allow for connections, and the masonry shall be carefully constructed around them so as to prevent leakage along the outer surfaces.
- **602.13 Curing and Protection.** After the masonry work is completed, it shall be kept moist and protected from the elements for a period of not less than 48 hours.
  - **602.14 Cleaning.** All catch basins, manholes, inlets, and similar structures newly constructed, adjusted or reconstructed under the contract, shall be cleaned of any accumulation of silt, debris, or foreign matter of any kind, and shall be free from such accumulations at the time of final inspection.
  - **602.15 Basis of Payment.** When new construction is specified, this work will be paid for at the contract unit price each for CATCH BASINS, MANHOLES, INLETS, DRAINAGE STRUCTURES, or VALVE VAULTS, of the type or type and diameter specified, and with the type of frame and grate or frame and lid specified or median inlet number specified, which price shall include all frames, grates, lids, concrete and reinforcement for aprons for median inlets, sand cushion, steps and flat slab tops, and all excavation and backfilling, except excavation in rock.

When adjustment or reconstruction is specified and existing frames, grates and lids are to be used, this work will be paid for at the contract unit price each for CATCH BASINS TO BE ADJUSTED, CATCH BASINS TO BE RECONSTRUCTED, MANHOLES TO BE ADJUSTED, MANHOLES TO BE RECONSTRUCTED, INLETS TO BE ADJUSTED, INLETS TO BE RECONSTRUCTED, VALVE VAULTS TO BE ADJUSTED, or VALVE VAULTS TO BE RECONSTRUCTED, which price shall include resetting the frame with grate or lid, and excavation and backfill, except excavation in rock.

When adjustment or reconstruction is specified and new frames, grates, lids or median inlets are to be used, this work will be paid for at the contract unit price each for CATCH BASINS TO BE ADJUSTED WITH NEW FRAME AND GRATE or LID. of the type specified, or WITH NEW MEDIAN INLET, of the number specified; CATCH BASINS TO BE RECONSTRUCTED WITH NEW FRAME AND GRATE or LID of the type specified, or WITH NEW MEDIAN INLET of the number specified; MANHOLES TO BE ADJUSTED WITH NEW FRAME AND GRATE or LID of the type specified, or WITH NEW MEDIAN INLET of the number specified; MANHOLES TO BE RECONSTRUCTED WITH NEW FRAME AND GRATE or LID of the type specified, or WITH NEW MEDIAN INLET of the number specified; INLETS TO BE ADJUSTED WITH NEW FRAME AND GRATE or LID of the type specified, or WITH NEW MEDIAN INLET of the number specified; INLETS TO BE RECONSTRUCTED WITH NEW FRAME AND GRATE or LID of the type specified, or WITH NEW MEDIAN INLET of the number specified; VALVE VAULTS TO BE ADJUSTED WITH NEW FRAME AND CLOSED LID of the type specified; or VALVE VAULTS TO BE RECONSTRUCTED WITH NEW FRAME AND CLOSED LID of the type specified; which price shall include all materials, including frames, grates, lids, concrete and reinforcement for aprons for median inlets, and the sand cushion, steps and flat slab tops, when required, and all excavation and backfilling, except excavation in rock.

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Additional reinforcement, when required for Type 15 Frames and Lids, will be included in the unit bid price of the type of structure specified.

Excavation in rock will be paid for according to the requirements of Section 502 for Rock Excavation for Structures.

# SECTION 603. ADJUSTING FRAMES AND GRATES OF DRAINAGE AND UTILITY STRUCTURES

- **603.01 Description.** This work shall consist of adjusting the frames, with grates or lids, of existing drainage and utility structures.
- **603.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 Materials:

	ltem	Article/Section
(a)	Portland Cement Concrete	1020
(b)	Building Brick (Clay or Shale)	1041.01
(c)	Concrete Building Brick	1041.02
(d)	Concrete Masonry Units	1042
(e)	Precast Reinforced Concrete Manhole Sections	1043
(f)	Gray Iron Castings	1006.14
(g)	Ductile Iron Castings	1006.15
	Structural Steel	

### **CONSTRUCTION REQUIREMENTS**

**603.03 Two-Course Bituminous Construction.** The existing pavement adjacent to and for a distance not exceeding 300 mm (12 inches) outside the base of the casting to be adjusted shall be broken sufficiently to permit its removal. The existing pavement shall be broken and the grates adjusted just prior to placing the surface course. If the existing pavement is broken prior to placing the first course, it shall not be removed until the first course has been placed and compacted. Where a casting is enclosed in a concrete platform, the entire platform shall be broken, removed and replaced.

Prior to placing the first course, the exposed surface of each casting shall be coated with an approved release agent to prevent the bituminous mixture from adhering to it. After the first course has been placed and compacted, the bituminous mixture over each drainage or utility structure and the existing pavement adjacent to the drainage or utility structure shall be removed. The broken pavement and bituminous mixture from these areas shall be disposed of by the Contractor as specified in Article 202.03.

The frames shall then be adjusted to the finished pavement elevation according to the applicable portions of Section 602.

**603.04 Single-Course Bituminous Construction.** Prior to placing the bituminous mixture, the existing pavement adjacent to and for a distance not exceeding 300 mm (12 inches) outside the base of the casting to be adjusted shall

be broken, removed and disposed of by the Contractor as specified in Article 202.03.

The frames shall then be adjusted to the finished pavement elevation according to the applicable portions of Section 602.

- **603.05** Replacement of Existing Flexible Pavement. After the castings have been adjusted, the surrounding space shall be filled with Class SI Concrete, or bituminous concrete surface or binder course material to the elevation of the surface of the base course or the binder course. If Class SI Concrete is used, it shall be cured for a period of not less than 72 hours. If bituminous concrete is used, it shall be placed in 75-mm (3-inch) layers at the required temperature and compacted with a pneumatic tamper.
- **603.06** Replacement of Existing Rigid Pavement. After the castings have been adjusted to the satisfaction of the Engineer, the pavement and bituminous mixture removed, shall be replaced with Class SI Concrete not less than 225 mm (9 inches) thick.

The surface of the Class SI Concrete shall be constructed flush with the surface of the adjacent bituminous mixture or pavement. Class SI Concrete shall be cured for a period of not less than 72 hours.

- **603.07 Protection Under Traffic.** After the casting has been adjusted and the Class SI Concrete has been placed, the work shall be protected by a barricade and 2 lights for at least 72 hours. Before final surfacing operations have been started in the immediate vicinity of the structure, a bituminous mixture shall be placed around the casting, flush with its surface and decreasing to a featheredge in a distance of 600 mm (2 ft.) around the entire surface of the casting. This mixture shall remain in place until surfacing operations are undertaken within the immediate area of the structure. Prior to placing the surface course, the temporary bituminous mixture shall be removed and disposed of by the Contractor as specified in Article 202.03.
- **603.08 Adjusting Rings.** Adjustment of frames and grates may be accomplished through the use of approved adjusting rings. Adjusting rings shall be gray or ductile iron. The adjusting rings shall be designed to provide a structural capacity equal to or greater than the existing or specified frame, shall not affect the opening size or surface appearance. The rings shall have a device for positively positioning and securely fastening the ring to the existing frame so as to match and maintain the surface grade and slope and prevent movement under traffic loadings.
- **603.09 Basis of Payment.** This work will be paid for at the contract unit price each for FRAMES AND GRATES TO BE ADJUSTED or FRAMES AND LIDS TO BE ADJUSTED, which price shall be payment in full for performing the work.



### SECTION 604. FRAMES, GRATES, AND MEDIAN INLETS

**604.01 Description.** This work shall consist of furnishing, and installing frames, grates, lids, covers, and median inlets where such items are not included in the cost of the drainage or utility structures involved.

**604.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 - Materials:

	Item	Article/Section
(a)	Gray Iron Castings	1006.14
	Structural Steel	
(c)	Ductile Iron Castings	1006.15
(d)	Portland Cement Concrete	1020
(e)	Reinforcement Bars and Fabric	1006.10

**604.03 Materials Permitted.** The materials permitted for fabrication of the various types of frames, lids, and grates and the various numbers of median inlets shall conform to the following:

Type or	F	0 1	121	
Number 1	Frame Gray Iron	Grate	Lid Gray Iron or	Cover
·	Gray IIOII		Ductile Iron	
3 & 3V	Gray Iron	Gray Iron or Ductile Iron		
4	Gray Iron	Gray Iron or Ductile Iron		
5	Gray Iron		Gray Iron or Ductile Iron	
6	Gray Iron	Gray Iron or Ductile Iron		
7		Gray Iron or Ductile Iron		
8		Gray Iron or Ductile Iron		
9	Gray Iron	Gray Iron or Ductile Iron		
10	Gray Iron	Gray Iron or Ductile Iron		
11&11V	Gray Iron	Gray Iron or Ductile Iron		
12	Gray Iron	Gray Iron or Ductile Iron		
15	Gray Iron		Gray Iron or Ductile Iron	
20	Gray Iron or Ductile Iron	Gray Iron or Ductile Iron*		
21	Gray Iron or Ductile Iron	Gray Iron or Ductile Iron*		
22	Gray Iron or Ductile Iron	Gray Iron or Ductile Iron*		
23	Gray Iron or Ductile Iron	Gray Iron or Ductile Iron*		
24	Gray Iron or Ductile Iron	Gray Iron or Ductile Iron*		
Median Inlet (2250)	Gray Iron	Ductile Iron		
Median Inlet (2251)	Gray Iron	Ductile Iron		
2A & 2B		Gray Iron or Ductile Iron		Gray Iron or Ductile Iron
A & B		Gray Iron or Ductile Iron		

<sup>\*</sup>Safety bars for the grates shall be of ductile iron.



#### CONSTRUCTION REQUIREMENTS

**604.04 General.** Frames placed on concrete or masonry surfaces shall be set in full mortar beds. The mortar shall be mixed in proportions of one part cement to three parts sand, by volume based on dry materials. Castings shall be set accurately to the finished elevation so that no subsequent adjustment will be necessary.

For Frames and Grates Type 6 and 12, a 2 piece frame may be used with the approval of the Engineer.

For Frames and Grates, Type 20, 21, and 22, the notch in the grate and the 14 mm (9/16 inch) diameter holes in the frame are for the insertion of 1 galvanized M12 (1/2 inch) diameter bolt and nut. The bolt and nut shall be placed as directed by the Engineer to provide for correct replacement of the grates during maintenance operations.

When Frames and Grates, Type 21, is used in conjunction with a precast concrete barrier, a gap of at least 600 mm (2 ft.) on both sides of the casting shall be provided to permit cast-in-place barrier to be constructed to incorporate the barrier box.



When Median Inlets (2250) and (2251) are specified, the concrete apron shall be constructed of Class SI Concrete and shall be reinforced with welded wire fabric consisting of 150 mm x 150 mm (6 inch x 6 inch) mesh, 5.7 mm (No. 4) wire, weighing 2.8 kg/m<sup>2</sup> (58 lbs./100 sq. ft.).

Additional reinforcement, when specified for Type 15 Frames and Lids, will be included in the unit bid price of the type of structure specified.

**604.05 Basis of Payment.** This work will be paid for at the contract unit price each for FRAMES, GRATES, FRAMES AND GRATES, FRAMES AND LID, and GRATES AND COVERS, of the type or types specified, and at the contract unit price each for MEDIAN INLETS of the number specified, which price shall include furnishing and setting the castings.

The unit price bid for Median Inlets shall include castings, concrete, and reinforcement for constructing the concrete apron.

The unit price bid for Frames and Grates, Type 22, shall include both frames and both grates, and the PAF filler placed between the 2 frames.

The unit price bid for Frames and Lids, Type 15, shall include the extra form work required by the special construction under CASE I or CASE II, and no additional compensation will be allowed.

## SECTION 605. REMOVING OR FILLING EXISTING MANHOLES, CATCH BASINS AND INLETS

- **605.01 Description.** This work shall consist of removing or filling existing manholes, catch basins, and inlets.
- **605.02 Materials.** Materials shall conform to the following Articles of Section 1000 Materials:

### Art. 605.02

### Removing or Filling Existing Manholes, Catch Basins and Inlets

	Item Article/So	ection
(a)	Portland Cement Concrete	1020
(b)	Brick	1041

#### **CONSTRUCTION REQUIREMENTS**

605.03 Removing Existing Manholes, Catch Basins, and Inlets. Existing manholes, catch basins and inlets designated to be removed at locations where the existing inlet and/or outlet pipes are to be abandoned, shall be removed for the full depth of structure. If the abandoned pipes are not designated to be removed, the ends of the pipe at the structure shall be sealed with Class SI Concrete or brick and mortar in a manner satisfactory to the Engineer. After the concrete or mortar has set, the hole formed by removal of the structure shall be backfilled with sand, placed and compacted to the satisfaction of the Engineer.

Existing manholes, catch basins and inlets designated to be removed at locations where flow is to be maintained in the existing storm sewer system or a proposed storm sewer is to be connected to the existing system, shall be removed to depth of at least 100 mm (4 inches) below the bottom of the storm sewer system. All debris in the structure below the storm sewer shall be removed and replaced with compacted sand to the approximate elevation of the bottom of the sewer. The existing storm sewer shall then be connected to maintain flow with pipe of the same kind and size as the existing pipe, or the proposed storm sewer shall be connected to the existing system, and the joints sealed. If a proper connection cannot be made at a joint in the existing sewer, a collar of Class SI Concrete shall be used to seal the joint. The hole formed by the removal of the structure shall then be backfilled with sand, placed and compacted to the satisfaction of the Engineer.

- **605.04** Filling Existing Manholes, Catch Basins, and Inlets. The tops of all existing manholes, catch basins and inlets to be filled shall be removed to an elevation of at least 75 mm (3 inches) below the earth subgrade of the proposed improvement. All inlet and/or outlet connections shall be securely sealed with Class SI Concrete or brick and mortar. After the concrete or mortar has set, the existing structure shall be filled with sand, placed, and compacted to the satisfaction of the Engineer.
- **605.05 Disposal of Excess Material.** All material resulting from the filling or removing of existing manholes, catch basins and inlets shall be disposed of by the Contractor according to the requirements of Article 202.03.
- **605.06 Basis of Payment.** The work of removing existing manholes, catch basins and inlets at locations where the existing inlet and/or outlet pipes are to be abandoned will be paid for at the contract unit price each for REMOVING MANHOLES, REMOVING CATCH BASINS, or REMOVING INLETS, which price shall include removing and disposing of the existing structure, sealing inlet and outlet pipes, and backfilling.

The work of removing existing manholes, catch basins and inlets at locations where flow is to be maintained in the storm sewer system will be paid for at the contract unit price each for REMOVING MANHOLES TO MAINTAIN FLOW, REMOVING CATCH BASINS TO MAINTAIN FLOW, or REMOVING INLETS TO MAINTAIN FLOW, which price shall include removing and disposing of the existing

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structure, materials and labor to connect the existing or existing and propose storm sewers to maintain flow, and backfilling the hole with sand.

The work of filling existing manholes, catch basins and inlets will be paid for at the contract unit price each for FILLING MANHOLES, FILLING CATCH BASINS or FILLING INLETS, which price shall include removing and disposing of the top portions of the structures as necessary, sealing existing pipes when necessary, and filling the existing structures with sand.

# SECTION 606. CONCRETE GUTTER, CURB, MEDIAN, AND PAVED DITCH



**606.01 Description.** This work shall consist of constructing concrete curb, concrete gutter, combination concrete curb and gutter, concrete median or paved ditch.

**606.02 Materials.** All materials shall meet the requirements of the following Articles of Section 1000 - Materials:

	Item	Article/Section
(a)	Portland Cement Concrete	1020
(b)	Reinforcement Bars (Note 1)	1006.10
(c)	Preformed Expansion Joint Filler	1051
(d)	Pavement Fabric	1006.10
		1023
		1006.11

Note 1. Tie bars shall be epoxy coated.

#### **CONSTRUCTION REQUIREMENTS**

**606.03 Excavation.** The subgrade shall be excavated according to the cross section shown on the plans. All unsuitable material shall be removed and replaced with suitable material, and the subgrade shall be compacted and finished to a firm, smooth surface.



**606.04** Forms. Forms shall be securely staked, braced and held firmly to the required line and grade, and shall be sufficiently tight to prevent leakage of mortar. All forms shall be cleaned and oiled before the concrete is placed against them.

With the approval of the Engineer, a slipform paver may be used. If a slipform paver is used, the concrete slump shall be adjusted to meet the tolerances for the type of work being performed. Vertical faces may be battered at the rate of 6 percent from vertical to aid in slipform operations.

**606.05 Placing Concrete.** The improved subgrade shall extend to the back of the curb. The subgrade and forms will be checked and approved by the Engineer before the concrete is placed. The subgrade shall be moistened prior to concrete placement. The concrete shall be thoroughly tamped and spaded or mechanically vibrated and finished smooth and even. Before the concrete is given the final finish,

the surface of the curb, curb and gutter, gutter or median will be checked with a 3-m (10-ft.) straightedge, and any irregularities of more than 6 mm (1/4 inch) in 3 m (10 ft.) shall be eliminated.

- **606.06** Concrete Gutter and Curb and Gutter. Joints in concrete gutter, curb, and combination curb and gutter shall be a continuation of the joints in the adjacent pcc pavement or base course. Expansion joints adjacent to drainage castings may be placed in prolongation with other joint types.
- Transverse joints in concrete curb and combination curb and gutter when constructed adjacent to flexible pavement shall be constructed according to the details shown on the plans. When concrete gutter is constructed adjacent to flexible pavement, two 32 mm (1 1/4 inch) diameter x 450 mm (18 inches) long dowel bars shall be installed in all transverse joints. The transverse joints shall be contraction joints spaced on 8-m (25-ft.) centers.

At points where the proposed or existing sidewalk or driveway pavement occupies the entire space between the proposed curb and an adjacent building or permanent structure, 25-mm (1-inch) preformed expansion joint shall be placed between the sidewalk, building, or driveway pavement and the proposed curb. The expansion joint material shall extend the entire depth of the sidewalk, or driveway pavement, or to such depth as will allow 25-mm (1-inch) expansion between the proposed curb and adjacent sidewalk, building or driveway pavement.



Longitudinal construction, transverse contraction, hinge, and expansion joints shall be constructed according to the applicable requirements of Article 420.10. Contraction and hinge joints shall be sawed to a depth equal to 1/3 the thickness of the gutter flag and to a width of not less than 3 mm (1/8 inch). The expansion joint filler material shall be cut to the exact cross section of the gutter, curb or combination curb and gutter. The bars in transverse hinge and contraction joints will be required for monolithic construction only. Dowel bars for expansion and contraction joints and tie bars for hinge joints in combination concrete curb and gutter shall be spaced as shown on the plans, except only 1 dowel bar or tie bar will be required at a joint if the width of the gutter is less than 450 mm (18 inches).

Transverse contraction and hinge joints and longitudinal construction joints shall be sealed according to the requirements of Article 420.14(a), except that transverse joints in concrete curb and gutter shall be sealed with an approved polysulfide sealer.

When combination concrete curb and gutter is constructed across alleys or private drives, or where directed by the Engineer, the top of curbs shall be depressed according to the details shown on the plans. The transition from full height curb to depressed curb shall be made in a distance equal to at least 4 times the difference in height from the full height to the depressed curb.

Areas of adjacent pcc pavement or base course less than 300 mm (12 inches) in width shall be constructed monolithic with the curb or combination curb and gutter. These areas of pavement or base course will be included in the measured areas of the adjacent pavement or base course. Where base course is specified to extend under the curb and gutter, the curb and gutter may be poured full depth of the pavement in lieu of the base course.

Curb and combination curb and gutter may be constructed monolithically with pcc pavement or base course greater than 300 mm (12 inches). Tie bars between the

slab and the gutter will not be required when constructed monolithically with pcc pavement, but will be required when constructed monolithically with pcc base course. The tie bars shall be held in the proper position by support pins or placed by approved mechanical means. Pavement reinforcement, when required in pavement, shall be extended laterally to within 75 mm (3 inches) to 125 mm (5 inches) from the back of the curb. The forming of longitudinal joints between the pcc pavement or base course and the curb or combination curb and gutter will not be required.

Transition from one type of gutter, curb or curb and gutter to another type shall be constructed according to the details shown on the plans or as directed by the Engineer.



**606.07** Inlets, Entrances and Outlets for Gutter and Curb and Gutter. Inlets, entrances and outlets for concrete gutter, and outlets for combination concrete curb and gutter shall be constructed according to the details shown on the plans or as directed by the Engineer.

The longitudinal and transverse joints shall be as specified in Article 606.06.

Pipe drains for outlets of the drop-box type shall be either corrugated steel or aluminum alloy pipe constructed according to the applicable requirements of Section 601. The grates and covers shall conform to the applicable requirements of Section 604.



**606.08 Concrete Medians.** Concrete medians shall be constructed at the locations, of the types, and according to the details shown on the plans or as directed by the Engineer.

For Type P surface median, grooves 25 mm (1 inch) deep shall be formed in the plastic concrete at 3-m (10-ft.) maximum intervals both transversely and longitudinally. Grooves also shall be formed at the corner points of all holes boxed out for sign and signal posts. A 20 mm (3/4 inch) diameter plastic tube shall be installed through the back of the curb at 30-m (100-ft.) intervals on the low side or sides of the median and 2 at the low end to provide drainage.



Aggregate fill, when required under paved median, shall be gradation CA 13, CA 14, CA 15, or CA 16 and shall be placed in layers 100 mm (4 inches) thick and compacted to the satisfaction of the Engineer.

Portland cement concrete pavement or base course less than 300 mm (12 inches) in width that is directly adjacent to concrete median shall be constructed monolithically with the median but the area will be included in the measured area of the adjacent pavement or base course.

The transverse joints in Type P surface median shall be expansion joints consisting of preformed expansion joint filler 20 mm (3/4 inch) thick, conforming to the full cross section of the median surface, and placed at intervals of 9 m (30 ft.) in the median surface. At least one joint shall be constructed in each median island.

For all other types of median when constructed adjacent to pcc pavement or base course, transverse joints shall be in prolongation with joints in the pavement or base course and shall be of the same type except that dowel bars or tie bars will not be required. For corrugated medians, the Contractor has the option of constructing the joints with 20 mm (3/4 inch) preformed expansion joint filler conforming to the full

cross section of the median. When constructed adjacent to flexible pavement, transverse joints shall be contraction joints at 6-m (20-ft.) intervals.



Contraction and hinge joints shall be formed by sawing to a depth of 1/3 the thickness of the median and sealed according to Article 420.14(a). Expansion joints shall be formed by placing 20-mm (3/4-inch) thick preformed expansion joint filler conforming to the full cross section of the median. When permitted by the Engineer, expansion joints may be substituted for contraction or hinge joints.



**606.09 Paved Ditch.** Paved ditch shall be constructed at the locations and according to the details shown on the plans or as directed by the Engineer.

Anchor walls shall be spaced at not more than 15-m (50-ft.) intervals along the paved ditch. Anchor walls and the cut-off wall shall be constructed monolithically with the paved ditch.

At the option of the Contractor, No. 10 (No. 3) reinforcing bars place at 300-mm (12-inch) centers longitudinally in the paved ditch and vertically in the anchor and cut-off walls may be used in lieu of the welded wire fabric.

A 13 mm (1/2 inch) thick preformed joint filler shall be placed at the junction of paved ditch with any other structure.

**606.10 Finishing.** All exposed surfaces shall be finished smooth and even, and given a light brush finish while the concrete is still workable. The edges shall be rounded with approved finishing tools having the radii shown on the plans.

Forms shall be removed within 24 hours after the concrete has been placed and minor defects shall be filled with mortar consisting of 1 part portland cement to 2 parts fine aggregate.

- **606.11 Protective Coat.** Protective coat, when required, shall be constructed according to Article 420.21.
- **606.12 Backfill.** After the concrete has obtained the specified strength or when directed by the Engineer, the spaces in front and back of the construction shall be backfilled to the required elevation with suitable material, compacted, and neatly graded to the satisfaction of the Engineer.



**606.13 Method of Measurement.** Concrete curb, concrete gutter, combination concrete curb and gutter and paved ditch will be measured for payment in meters (feet) in the flow line of the gutter or paved ditch and along the face of concrete curb, which measurement will include drainage castings incorporated in various curbs and curbs and gutters but will exclude entrances, inlets and outlets for gutters and outlets for combination curb and gutters. The lengths of transitions from one type of gutter or curb and gutter to another will be included in the measured quantities for the types having the largest cross sectional areas of concrete.

The various types of concrete median will be measured for payment in place and the area computed in square meters (square feet). Concrete curb and gutter around solid concrete median will not be measured separately for payment. Concrete curb and gutter around Type P median surface will be measured separately for payment in meters (feet). The areas of ramp noses will be included in the measured

quantities of concrete medians in which they are included.

Concrete inlets, entrances and outlets for gutters and outlets for combination curb and gutter will be measured for payment in place and the volume of concrete computed in cubic meters (cubic yards). Pipe drains for outlets of the drop box type will be measured for payment as specified in Article 601.07.

**606.14 Basis of Payment.** Concrete gutter, curb and combination curb and gutter will be paid for at the contract unit price per meter (foot) for CONCRETE GUTTER, CONCRETE CURB or COMBINATION CONCRETE CURB AND GUTTER, of the type specified, which price shall include furnishing and placing all concrete, base course, tie bars and joints, and all labor for completing the work.

Concrete median will be paid for at the contract unit price per square meter (square foot) for CORRUGATED MEDIAN; CONCRETE MEDIAN SURFACE, 100 MM (4 INCH) or CONCRETE MEDIAN, of the type specified. For solid concrete median the unit price will also include concrete curb and gutter.

Concrete inlets, entrances and outlets for gutter and outlets for combination curb and gutter will be paid for at the contract unit price per cubic meter (cubic yard) for CLASS SI CONCRETE (OUTLET). Grates and grates and covers used with drop box type outlets will be paid for as specified in Article 604.05. Pipe drains for drop box type outlets will be paid for as specified in Article 601.08.

Paved ditch will be paid for at the contract unit price per meter (foot) for PAVED DITCH, of the type specified, which price shall include furnishing and placing all concrete, preformed joint filler, welded wire fabric reinforcement or reinforcement bars, and constructing anchor and cut-off walls.

Protective Coat will be paid for as specified in Article 420.23.

Excavation required in the performance of the work will be measured and paid for as provided in Section 202.

### **SECTION 607. SLUICE GATE**

- **607.01 Description.** This work shall consist of furnishing, fabricating, transporting and installing a sluice gate of the size shown on the plans with all the necessary appurtenances.
- **607.02 Materials.** Materials shall meet the requirements of AWWA C501 Section 2 Materials.

# **CONSTRUCTION REQUIREMENTS**

**607.03 General.** The sluice gate shall be constructed in such a manner as to meet the requirements of AWWA C501 Section 3 - General Design and Section 4 - Fabrication.

All wedges shall be provided with wedge adjusting screws and lock nuts.

All manual floor stands shall be provided with clear butyrate plastic pipe covers

with mylar position indicator.

- **607.04 Painting.** All cleaning, painting, and protecting of the sluice gate shall be according to AWWA C501 Section 3.13 Painting. A finish coat of black asphalt base coating shall be applied in the field to all submerged parts. The lifting device shall be painted with a machinery enamel suitable for outdoor service.
- **607.05 Installation.** The sluice gate shall be installed and tested according to AWWA C501 Section 6 Installation.
- **607.06 Drawings and Manuals.** Before any fabrication has begun, the Contractor shall submit four complete sets of shop drawings to the Engineer for approval.

Four copies of the manual giving complete information on installation, lubrication and maintenance shall be provided to the Engineer by the Contractor.

**607.07 Basis of Payment.** This work will be paid for at the contract unit price each for SLUICE GATE, of the type and size specified, which price shall include furnishing and installing the sluice gate complete and operating, including assembling as recommended by the manufacturer, installation of a wall thimble when required, and field painting.

#### **SECTION 608. FLAP GATES**

- **608.01 Description.** This work shall consist of furnishing, fabricating, painting, transporting and installing a flap gate of the size, shape and design head shown on the plans together with the necessary appurtenances.
- **608.02 Materials.** Materials shall meet the requirements of the following Article of Section 1000 Materials:

		Item Article/So	ection
(a)	Flap Gate		1044

#### CONSTRUCTION REQUIREMENTS

- **608.03 Fabrication.** Before fabrication of the component parts of the flap gate is initiated, shop drawings showing the dimensions and details required to locate and install the component assemblies shall be submitted for the Engineer's approval.
- **608.04 Installation.** Prior to initiating installation of the flap gate, the Contractor shall provide the Engineer with 4 copies of a manual giving complete information on installation, lubrication, and maintenance of the flap gate.

The flap gate shall be installed according to the manufacturer's recommendations and as directed by the Engineer. The gate shall be installed in a plumb position with the axis of the hinge perpendicular to the centerline of the waterway opening.

The quantity and size of the fasteners shall be as recommended by the manufacturer. Flat back seat gates attached to concrete shall be mounted on anchor bolts and grouted in place. The anchor bolts shall be furnished with 2 nuts each to

facilitate installation and alignment.

**608.05** Basis of Payment. Flap gates will be paid for at the contract unit price each for FLAP GATE, of the size specified.



# SECTION 609. BRIDGE APPROACH PAVEMENT AND SHOULDER PAVEMENT DRAINS

- **609.01 Description.** This work shall consist of constructing bridge approach pavement drains and bridge approach shoulder pavement drains according to the details shown on the plans.
- **609.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 Materials:

	Item	Article/Section
(a)	Portland Cement Concrete	1020
(b)	Gray Iron Castings	1006.14
	Ductile Iron Castings	
	Structural Steel	
(e)	Reinforcement Bars	1006.10
(f)	Bedding Layer (Note 1)	1004.01

Note 1: Gradation CA 6, CA 10, or CA 12 of D quality or better.

Steel frames shall be galvanized after fabrication according to the requirements of AASHTO M 111.

# **CONSTRUCTION REQUIREMENTS**

- **609.03 Inlet Boxes.** Inlet boxes shall be either cast-in-place of Class SI Concrete according to the applicable requirements of Section 503 or precast of Class PC Concrete according to the applicable requirements of Section 504. Shop drawing for precast inlet boxes will not be required. A 75-mm (3-inch) thick bedding layer shall be provided under the full length and width of precast units.
- **609.04 Frames and Grates.** Either steel or cast iron frames shall be used. Cast grates shall be used and shall seat firmly in the frame.
- **609.05 Pipe Drains.** Pipe drains shall conform to the requirements of the applicable portions of Section 601, except that the material shall be corrugated steel, aluminum alloy, or polyethylene (PE) pipe, sand bedding will not be required, and corrugated steel and aluminum alloy pipe shall have 600 mm (2 ft.) couplings.

All pipe connections shall be watertight and all voids around the pipe drain entrance shall be sealed with mortar both inside and outside the inlet box.

When steel or aluminum pipe is used the end section shall be of the same material as the pipe. When polyethylene (PE) pipe is used the end section shall be steel or aluminum.

- **609.06 Thrust Blocks.** Thrust blocks, when required, shall be cast-in-place of Class SI Concrete. Thrust blocks will not be required when the difference in elevation between the inlet box invert and pipe drain outfall is less than 900 mm (3 ft.).
- **609.07** Basis of Payment. Inlet boxes complete in place will be paid for at the contract unit price each for TYPE B, C, or D INLET BOX STANDARD 609001 or TYPE C or D INLET BOX STANDARD 609006.

Pipe drains will be measured and paid for as specified in Section 601.

End sections for corrugated steel, aluminum, or polyethylene (PE) pipe will be paid for at the contract unit price each for METAL END SECTIONS of the diameter specified, which price shall include furnishing and installing the end section complete in place, including the toe plate, excavating, backfilling and connecting to the pipe.

Thrust blocks will be paid for at the contract unit price each for CONCRETE THRUST BLOCKS.



# **SECTION 610. SHOULDER INLETS WITH CURB**

- **610.01 Description.** This work shall consist of constructing shoulder inlets with curb according to the details shown on the plans and as specified.
- **610.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 Materials:

	Item	Article/Section
(a)	Portland Cement Concrete	1020
	Gray Iron Castings	
(c)	Ductile Iron Castings	1006.15
(d)	Structural Steel	1006 04
(e)	Reinforcement Bars	1006.10
(f)	Reinforcement Bars	1006.37

#### CONSTRUCTION REQUIREMENTS

- **610.03 Inlet Boxes.** Inlet boxes shall be constructed as specified in Article 609.03.
- **610.04** Frames and Grates. Frames and Grates shall be according to the requirements of Article 609.04.
- **610.05 Pipe Drains.** Pipe Drains shall be constructed as specified in Article 609.05.
- **610.06 Thrust Blocks.** Thrust blocks shall be constructed according to the requirements of Article 609.06

**610.07 PCC Slab.** The pcc slab shall be constructed of Class SH Concrete according to the applicable requirements of Section 483.

When shoulder inlets are constructed in conjunction with new bituminous shoulders, the bituminous shoulder shall be constructed first and then sawed full depth and removed in the area of the pcc slab. The area of bituminous shoulder removed for the construction of the pcc slab will be included in the area of bituminous shoulders measured for payment.

When the pcc slab is constructed in conjunction with new portland cement concrete shoulders, the slab may be constructed separately or monolithically with the shoulders at the option of the Contractor.

The lengths of reinforcement bars used in the pcc slab shall be such as to accommodate the lengths, width, and spacing shown on the plans, or as directed by the Engineer.

- **610.08 Shoulder Curb.** When shoulder inlets are constructed in conjunction with new bituminous shoulders, a bituminous curb shall be constructed according to the requirements of Section 661. When shoulder inlets are constructed in conjunction with new portland cement concrete shoulders, a pcc shoulder curb shall be constructed according to the requirements of Section 662.
- **610.09 Basis of Payment.** Inlet boxes complete in place will be paid for at the contract unit price each for TYPE E INLET BOX, STANDARD 610001 or TYPE F INLET BOX, STANDARD 610001, which price shall include all concrete and reinforcement bars, frame and grates, excavation, bedding when required, and backfilling.

Pipe drains will be measured and paid for as specified in Section 601.

End section for corrugated steel, aluminum or polyethylene (PE) pipe will be paid for at the contract unit price each for METAL END SECTIONS of the diameter specified, which price shall include furnishing and installing the end section complete in place, including the toe plate, excavating, backfilling, and connecting to the pipe.

Thrust blocks will be paid for according to Article 609.07.

The pcc slab will be paid for at the contract unit price per square meter (square yard) for PORTLAND CEMENT CONCRETE SHOULDERS, of the thickness specified, measured as specified in Article 483.11 except that a deduction will be made for the area displaced by the inlet box, which price shall include sawing, removal and disposal of the bituminous shoulder, subgrade preparation, and furnishing and placing concrete, reinforcement bars, and tie bars or expansion anchor ties.

Shoulder curb will be measured and paid for as specified in Section 661 or Section 662.

#### SECTION 611. TREATMENT OF EXISTING FIELD TILE SYSTEMS

**611.01 Description.** This work shall consist of locating and treating existing field tile systems within the limits of the right of way.

#### CONSTRUCTION REQUIREMENTS

- **611.02** Locating Existing Field Tile. Existing field tile in those areas where they are reported or suspected to exist shall be located by constructing exploration trench according to the requirements of Section 213. The depth of the exploration trench shall be 1.3 m (52 inches).
- **611.03** Existing Field Tile Intercepted by Backslopes. Existing field tile which are intercepted by the backslopes of the roadway after the ditches have been cut shall have the upstream ends tightly sealed with Class SI Concrete or brick and mortar to the satisfaction of the Engineer.

If specified on the plans or required by the Engineer, the existing field tile within the limits of the pavement and paved shoulders shall be removed or crushed. Removing or crushing existing field tile shall be accomplished by constructing exploration trench along the line of the tile. All trenches cut for the purpose of removing or crushing existing tile within the limits of 600 mm (2 ft.) outside the proposed pavement and paved shoulders shall be backfilled to the existing ground line in fill sections and to the elevation of the earth subgrade in cut sections with trench backfill meeting the requirements of Section 208 and compacted as specified in Article 550.07.

Pipe drains, conforming to the applicable requirements of Section 601, shall be used for the terminal 3 m (10 ft.) of the existing field tile where it is outletted into the roadway ditch. The pipe drain shall be a single length section of a diameter equal to the diameter of the existing field tile plus 50 mm (2 inches), but not less than 150 mm (6 inches).

Pipe drains outletting into a roadway ditch shall have a concrete headwall constructed at the outlet end according to the details shown on the plans. The headwall shall be constructed of Class SI Concrete according to the applicable requirements of Section 503.

**611.04 Field Tile Not Intercepted by Backslopes.** Storm sewer shall be used to replace existing field tile within the right of way at locations where the existing tile crosses under the roadway and below the roadway ditches, and shall be constructed according to the requirements of Section 550.



Storm Sewer Protected shall be additional protection provided for the storm sewer at roadway ditches by constructing a concrete slab or paved ditch section over the pipe according to the details shown on the plans. The concrete slab shall be used whenever the cover over the slab at the bottom of the ditch is 100 mm (4 inches) or more. The paved ditch section shall be used when the cover is less than 100 mm (4 inches). The concrete slab and paved ditch section shall be constructed of Class SI Concrete according to the applicable requirements of Section 503.

Storm Sewer (Special) shall be used to replace existing field tile within the right of way at locations where the existing tile does not cross under the roadway and is not outlet into the roadway ditch. The kinds of material permitted for Storm Sewer (Special) shall be according to Article 550.03 for Storm Sewers, Type 2. Storm Sewer (Special) shall be constructed according to the requirements of Section 550, except that in lieu of the sand bedding the pipe may be installed as specified in Article 601.03 and joints between pipe sections shall not be sealed.

At locations where Storm Sewer (Special) is outlet into a ditch, a concrete headwall corresponding to that specified in Article 601.05 for pipe drains shall be constructed at the outlet end.

**611.05 Field Tile Junction Vaults.** Field tile junction vaults, shall be used at locations where 2 or more drain lines intersect, where a sharp directional change of flow is required, or where storm sewer or Storm Sewer (Special) connects to existing field tile. Field tile junction vaults shall be constructed according to the details shown on the plans and the applicable requirements of Section 602. Frame and grate, when required, shall be cast iron. All junctions between pipes and vault shall be sealed with mortar consisting of 1 part portland cement to 2 parts sand.



**611.06 Method of Measurement.** Exploration trench for locating existing field tile and for removing or crushing existing field tile will be measured for payment in meters (feet) of actual trench constructed.

Storm Sewers and Storm Sewers (Special) of the various diameters will be measured for payment in place in meters (feet).

Concrete headwalls, concrete slabs and paved ditch sections will be measured for payment in place and the volume computed in cubic meters (cubic yards).

**611.07 Basis of Payment.** Locating existing field tile and removing or crushing existing field tile will be paid for at the contract unit price per meter (foot) for EXPLORATION TRENCH [1.3 m (52 inch) DEPTH], which price shall include backfilling the trench and replacement of broken tile as required.

Pipe drains will be measured and paid for as specified in Section 601.



Storm Sewer Protected will be paid for at the contract unit price per meter (foot) for STORM SEWER, PROTECTED, of the diameter specified, which price shall include all pipe fitting and all other materials except trench backfill, all excavation except excavation in rock, backfilling, providing all sheeting or shoring.

Storm Sewer (Special) will be paid for at the contract unit price per meter (foot) for STORM SEWER (SPECIAL), of the diameter specified, which price shall include all pipe fittings and other materials required, all excavation except excavation in rock, backfilling, and all sheeting and shoring.

Concrete headwalls, concrete slabs and paved ditch sections required for this work will be paid for at the contract unit price per cubic meter (cubic yard) for MISCELLANEOUS CONCRETE, which price shall include the welded wire fabric reinforcement and all excavation and backfill.

Field tile junction vaults will be paid for at the contract unit price each for FIELD TILE JUNCTION VAULTS, of the diameter specified, which price shall include furnishing and placing the sand cushion when required and the frame and grate or precast concrete lid.

Trench backfill will be measured and paid for as specified in Section 208.

Excavation in rock will be measured and paid for as specified in Section 502 for Rock Excavation for Structures.

Removal and replacement of unsuitable material below bedding grade will be

# Art. 611.07 Treatment of Existing Field Tile Systems

paid for according to Article 109.04.

Sealing the ends of existing field tile will not be paid for as a separate item, but shall be considered as included in the unit prices bid for the various pay items of work involved.

#### SAFETY RELATED ITEMS



# SECTION 630. STEEL PLATE BEAM GUARDRAIL

- **630.01 Description.** This work shall consist of furnishing and erecting steel plate beam guardrail and posts.
- **630.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 Materials:

	Item		Article	Section
(a)	Rail Element Plates, End Section Plates, and	Splice Plate	s	1006.25
(b)	Bolts, Nuts, Washers, and Hardware			1006.25
(c)	Wood Posts and Wood Block	1007.01,	1007.02,	1007.06
(d)	Steel Posts, Blockouts, Restraints and Wire F	Rope for Gua	ırdrail	1006.04
(e)	Preservative Treatment			1007.12
(f)	Portland Cement Concrete			1020
(g)	Reinforcement Bars			1006.10

#### CONSTRUCTION REQUIREMENTS

**630.03 General.** When steel block-outs are mounted on wood posts, M16 (5/8 inch) diameter by 90-mm (3 1/2-inch) long lag screws installed in pre-drilled holes shall be used in lieu of the post bolts and nuts. All holes in posts and blockouts shall be 19 mm (3/4 inch)

Load tests shall be conducted on 10 percent of all expansion anchor bolts used in guardrail installation. The tests shall be conducted in the presence of the Engineer. The equipment and method used shall meet the approval of the Engineer. The minimum test load shall be 35 kN (8000 lbs.) for M22 (7/8 inch) diameter bolts and 13 kN (3000 lbs.) for M16 (5/8 inch) diameter bolts in direct pull. For each anchor bolt that fails the test, 2 more anchor bolts selected by the Engineer shall be tested. Each anchor bolt that fails to meet the test requirements shall be reset, or removed and the hole drilled deeper and reset, and retested until the anchor bolt passes the local test.

All rail elements shall be lapped in the direction of traffic in the adjacent lane.

**630.04 Fabrication.** The plates for the rail element shall be blanked to proper shape, fabricated and ready for assembly when received. No punching, drilling, cutting or welding will be permitted in the field. The plates shall be of uniform section. Deformed plates will be rejected. The edges of the plates shall be rolled or rounded so that they present no sharp edges. All connections and splices shall be made with button head bolts with oval shoulders, or in such a manner that there shall be no appreciable projection on the road side of the guardrail.

Where steel plate beam guardrail is constructed on curves which have a radius of 45 m (150 ft.) or less, the rail element plate shall be shop curved to the proper radius with the road side of the rail either concave or convex as required.

Plate ends in lap splices shall make contact throughout the entire area of the splice. All bolts in curved or deformed portions of the rail element shall be fabricated in such a manner that satisfactory bearing is obtained under the bolt head.

Each length of guardrail shall be finished at the ends as shown on the plans. Rail elements shall be furnished in nominal lengths of either 3.8 m (12 ft.-6 inches) or 7.6 m (25 ft.-0 inch).

**630.05 Posts.** Wood posts and blocks shall be treated. The posts and blocks shall be cut to the proper dimensions before treatment. No cutting of the posts or blocks will be permitted after treatment. Posts shall be erected according to Article 634.05.

If steel posts are used, they may be driven by hand or mechanical methods provided they are protected by a suitable driving cap and the earth around the posts compacted, if necessary, after driving. When steel posts are driven to incorrect alignment or grade, they shall be removed and set according to Article 634.05.

Only steel posts shall be used when the guardrail is mounted on existing culverts. When it is necessary to shorten the posts in the field, the lower portion shall be cut off in a manner to provide a smooth cut with minimum damage to the galvanizing. Cut areas shall be repaired according to the requirements of AASHTO M 36M (M 36).



**630.06** Shoulder Stabilization at Guardrail. Shoulder stabilization shall be constructed at the locations of steel plate beam guardrail installation according to the details shown on the plans. On new construction projects, the material used in the shoulder stabilization shall be the same as that used in the adjacent paved shoulder. On shoulder resurfacing projects, the material used in the shoulder stabilization shall be the same as that used for the shoulder resurfacing.

When portland cement concrete is used, shoulder stabilization shall be constructed according to the applicable requirements of Section 483. The shoulder stabilization shall be constructed simultaneously with the adjacent portland cement concrete shoulder. Guardrail posts shall be driven through round blockouts or holes cored in the completed shoulder stabilization. The voids around the posts shall be backfilled with a bituminous mixture approved by the Engineer.

When bituminous concrete is used, shoulder stabilization shall be constructed according to the applicable requirements of Section 482. On new construction, the shoulder stabilization shall be constructed simultaneously with the bituminous shoulder. On shoulder resurfacing projects, the portion of the shoulder stabilization below the surface of the existing paved shoulder shall be placed and compacted separately. The guardrail posts shall be driven through holes cored in the completed shoulder stabilization and the voids around the posts shall be backfilled with a bituminous mixture approved by the Engineer.

**630.07 Method of Measurement.** Steel Plate Beam Guardrail will be measured for payment in meters (feet). The length measured will be the overall length of the single or double rail erected measured along the top edge of the rail elements to the limits shown on the plans. Two rails attached to a single post will be measured as double rail.

Steel plate beam guardrail mounted on existing culverts will be measured for payment in meters (feet) extending from center to center of the first post driven adjacent to the structure.

Portland cement concrete shoulder stabilization at guardrail will be measured for

payment as specified in Article 483.11. Bituminous shoulder stabilization at guardrail will be measured for payment as specified in Article 482.08.

**630.08** Basis of Payment. This work will be paid for at the contract unit price per meter (foot) for STEEL PLATE BEAM GUARDRAIL, of the type specified.

When end sections are specified, they will not be paid for as a separate item, but shall be considered as included in the unit price for Steel Plate Beam Guardrail.

Steel plate beam guardrail mounted on existing culverts will be paid for at the contract unit price per meter (foot) for STEEL PLATE BEAM GUARDRAIL, ATTACHED TO STRUCTURES, which price shall include special posts and attachments for connecting the guardrail to existing culverts.

Portland cement concrete shoulder stabilization at guardrail will be paid for as specified in Article 483.12.

Bituminous shoulder stabilization at guardrail will be paid for as specified in Article 482.09.

Excavation in rock will be paid for as specified in Section 502 for Rock Excavation for Structures.



# **SECTION 631. TRAFFIC BARRIER TERMINALS**

- **631.01 Description.** This work shall consist of furnishing and erecting traffic barrier terminals.
- **631.02 Materials.** Materials shall meet the requirement of the following Articles of Section 1000 Materials:

	Item	Article/Section
(a)	Rail Element Plates, End Section Plates,	and Splice Plates 1006.25
(b)	Bolts, Nuts, Washers and Hardware	1006.25
(c)	Wood Posts and Wood Block	1007.01, 1007.02, 1007.06
(d)	Preservative Treatment	1007.12
(e)	Steel Posts	1006.04
(f)	Rubrail, Structural Shapes, and Plates	1006.04
(g)	Preservative Treatment	1007.12
(ĥ)	Hollow Structural Tubing	1006.27(b)

#### CONSTRUCTION REQUIREMENTS



- **631.03 General.** Traffic barrier terminals shall be constructed according to the requirements of Articles 630.03 through 630.05.
- **631.04 Traffic Barrier Terminal, Type 1B.** The excavated area around the buried portion of the terminal shall be backfilled according to the requirements of Article 502.10 except that granular material shall not be used.
- **631.05** Traffic Barrier Terminal, Type 4. When the pavement is on a curved alignment, the guardrail in the traffic barrier terminal assembly shall be curved to

match the alignment.

- **631.06 Traffic Barrier Terminal, Type 5 and Type 5A.** The face of the guardrail shall be installed flush with the face of the bridge rail or parapet.
- **631.07 Traffic Barrier Terminal, Type 6.** When attaching the end shoe to concrete, constructed with forms, and with a thickness of 300 mm (12 inches) or less, the holes may be formed, core drilled, or an approved 20 mm (3/4 inch) cast-in-place insert may be used.

When attaching the end shoe to concrete, constructed with forms and with a thickness greater than 300 mm (12 inches), an approved M20 (3/4 inch) bolt with an approved expansion device may be used, in lieu of core drilled or formed holes.

When attaching the end shoe to concrete constructed by slipforming, the holes shall be core drilled unless otherwise approved by the Engineer.

Wood block outs shall be used on all slope faced appurtenances.

**631.08** Traffic Barrier Terminal, Type 8. The rail section on the turned down curb connector shall be a 7.6-m (25-ft.) long section.

When a bridge expansion joint exists between the end shoe and the first post, all splice bolts and the end shoe and post bolts at the brackets shall be fitted with a lock nut or double nut and tightened only to a point that will allow guardrail movement.

**631.09** Traffic Barrier Terminal, Type 10. If any portion of the existing name plate of the bridge will be covered by the end shoe, the name plate shall be moved to an adjacent area along the rail or end post before the end shoe is installed.

The standard end shoe shall be attached to the existing concrete with pre-drilled or self-drilling anchor bolts. The anchor cone shall be set flush with the surface of the concrete. Externally threaded studs protruding from the surface of the concrete will not be permitted. The standard end shoe shall be placed between the splice plate and the rail element.

The distance between any anchor and the edge of existing concrete shall be 150 mm (6 inches).

When a bridge expansion joint exists between the end shoe and the first post, all splice bolts at the end shoe shall be fitted with a lock nut or double nuts and tightened only to a point that will allow guardrail movement.

- **631.10 Method of Measurement.** The various types of traffic barrier terminals will be measured for payment complete in place in units of each. The pay limit between the traffic barrier terminal and the adjacent guardrail shall be as shown on the plans, except that it shall be at the centerline of the end shoe splice for Traffic Barrier Terminal, Type 10.
- **631.11 Basis of Payment.** This work will be paid for at the contract unit price each for TRAFFIC BARRIER TERMINAL, of the type specified, which price shall include furnishing and installing all parts and materials, all excavation except excavation in rock, all backfilling, and moving of existing name plates when required.

The contract unit price each for TRAFFIC BARRIER TERMINAL, TYPE 11, shall

include any relocation of the traffic barrier terminal required in conjunction with the relocation of the Temporary Bridge Rail but does not include the Temporary Concrete Barrier.

The contract unit price each for TRAFFIC BARRIER TERMINAL, TYPE 3A, shall include drilling the holes and attaching the terminal to the Concrete Barrier but does not include the Concrete Barrier.

The contract unit price each for TRAFFIC BARRIER TERMINAL, TYPE 4A, shall include the cost of the end section.

Excavation in rock will be paid for as specified in Section 502 for Rock Excavation for Structures.

When widening of existing shoulders is required for the construction of traffic barrier terminals, the earthwork will be paid for as specified in Section 205 for Embankment.

### SECTION 632, GUARDRAIL AND CABLE ROAD GUARD REMOVAL

**632.01 Description.** This work shall consist of the removal and disposal of existing guardrail and cable road guard.

#### CONSTRUCTION REQUIREMENTS

- **632.02 General.** The guardrail and cable road guard shall be removed so that all material considered suitable by the Engineer for future use shall be salvaged. Posts having salvage value shall be removed without damage and those having no salvage value shall be pulled, or cut off at least 150 mm (6 inches) below the ground surface. All holes shall be filled and tamped. The salvaged material shall be stored at locations and in a manner approved by the Engineer. Any of this material having salvage value and which has been damaged by the Contractor shall be replaced at his/her own expense with new material of the same kind.
- **632.03 Method of Measurement.** Guardrail and cable road guard removal will be measured for payment in meters (feet), measured from center to center of end posts.
- **632.04 Basis of Payment.** This work will be paid for at the contract unit price per meter (foot) for GUARDRAIL REMOVAL or CABLE ROAD GUARD REMOVAL, which price shall include removing end sections and traffic barrier terminals, storing all salvageable material, and disposing of all materials that are not to be salvaged.

#### SECTION 633. REMOVING AND REFRECTING GUARDRAIL AND TERMINALS

- **633.01 Description.** This work shall consist of the complete removal and reerection of existing steel plate beam guardrail and traffic barrier terminals, or the rail elements of existing steel plate beam guardrail and traffic barrier terminals.
- **633.02 Materials.** New materials, when required, shall conform to the requirements of Articles 630.02 and 631.02.

#### CONSTRUCTION REQUIREMENTS

**633.03 General.** The removal and reerection of existing steel plate beam guardrail and traffic barrier terminals shall be performed according to the applicable requirements of Sections 630, 631 and 632.

New bolts, nuts and washers shall be used throughout in the reerection work. When specified on the plans, existing wood posts shall be replaced with new steel posts and existing blockouts shall be replaced with new adjustable steel blockouts. Rail elements and posts that are damaged during removal or that are otherwise unsatisfactory for reerection shall be replaced.

Existing bolts shall be removed by removing or shearing the nuts. The use of a cutting torch to remove existing bolts will not be allowed.

When removal and reerection includes the rail element only, the guardrail shall be temporarily stored against the posts or at the shoulder line. The existing posts shall not be exposed overnight without rail elements.

The complete guardrail, guardrail elements and traffic barrier terminals shall be reerected at the locations and according to the details shown on the plans.

**633.04 Method of Measurement.** The complete removal and reerection of the various types of steel plate beam guardrail will be measured for payment in meters (feet) in place at the location of reerection.

The complete removal and reerection of the various types of traffic barrier terminals will be measured for payment in place at the location of reerection in units of each as specified in Article 631.10.

The removal and reerection of the rail elements of steel plate beam guardrail and adjoining traffic barrier terminals will be measured for payment in meters (feet), measured from center to center of end posts.

633.05 Basis of Payment. The work of complete removal and reerection will be paid for at the contract unit price per meter (foot) for REMOVE AND REERECT STEEL PLATE BEAM GUARDRAIL, of the type specified, and at the contract unit price each for REMOVE AND REERECT TRAFFIC BARRIER TERMINALS, of the type specified. These prices shall include removal and temporary storage if necessary, furnishing new bolts, nuts and washers, furnishing new posts and blockouts when specified, and the reerection at the same location, including all excavation and backfill except excavation in rock. Replacement of unsatisfactory rail elements and posts except those damaged during removal and required to be replaced by the Contractor at his/her own expense will be paid for according to Article 109.04.

The work of removal and reerection of rail elements only will be paid for at the contract unit price per meter (foot) for REMOVE AND REERECT RAIL ELEMENT OF EXISTING GUARDRAIL, which price shall include furnishing new bolts, nuts and washers, and replacing existing blockouts with new adjustable steel blockouts when specified. Replacement of unsatisfactory rail elements except those damaged during removal which will be required to be replaced by the Contractor at his/her own expense will be paid for according to Article 109.04.

Excavation in rock will be paid for as specified in Section 502 for Rock Excavation for Structures.

#### **SECTION 634. GUARD POSTS**

- **634.01 Description.** This work shall consist of furnishing and setting guard posts.
- **634.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 Materials:

	Item		Article/Section
(a)	Guard Posts	1007.01, 10	07.02, 1007.09
(b)	Preservative Treatment		1007.12

#### CONSTRUCTION REQUIREMENTS

- **634.03** Preparation of Posts. The bottom of the posts shall be sawed square, and the tops shall be rounded to a hemisphere. This sawing and rounding shall be performed at the source of supply, and not in the field. All posts shall be peeled by removing all of the rough bark and at least 80 percent of the inner bark. All knots and projections shall be shaved smooth and flush with the surrounding wood.
- **634.04 Preservative Treatment.** The posts shall be pressure treated after the sawing and rounding have been performed.
- **634.05 Setting Posts.** The posts shall be set in compacted soil. The material in the bottom of the post holes shall be compacted to provide a stable foundation. The posts shall be set plumb with the front faces forming a smooth line. After the posts are in place, the holes shall be backfilled in layers with approved materials compacted in such a manner as not to displace the posts from correct alignment.

In lieu of setting posts in previously dug holes, the posts may be driven provided they are protected by a suitable driving cap, no damage is done to any portion of the post, they are driven plumb to the required depth and alignment with adequate lateral stability, and provided that the shoulders and adjacent slopes are not damaged from the driving operations. When, in the opinion of the Engineer, driving operations are producing unsatisfactory results, the posts shall be set in dug or bored holes.

**634.06 Basis of Payment.** This work will be paid for at the contract unit price each for GUARD POSTS, which price shall include furnishing and setting the posts, all excavation except excavation in rock, and backfilling.

Excavation in rock will be paid for as specified in Section 502 for Rock Excavation for Structures.



**635.01 Description.** This work shall consist of furnishing, installing, removing, and reinstalling delineator posts and reflectors.

Art. 635.02 Delineators

**635.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 - Materials:

	Item Article	e/Section
(a)	Metal Posts for Highway Markers, Signs and Delineators	1006.29
(b)	Reflectors for Delineators	1097.03

#### CONSTRUCTION REQUIREMENTS

- **635.03 General.** Delineators shall be spaced as shown on the plans. The spacing shall be carried across structures without interruption by means of bracket mountings fastened to the bridge rail. If the designated spacing causes a delineator location to occur at a pier of an overhead structure, the delineator may be omitted. When steel posts are used, they shall be unfinished.
- **635.04** Installing New Delineator Posts and Reflectors. Only one type of reflector and geometric shape will be permitted within the limits of a contract. The color of the reflectors shall be the same as the adjacent edge line.

For qualification purposes only, 3 samples required for tests shall be submitted by the Contractor. In addition, the Engineer will select 3 samples at random from each shipment for acceptance purposes.

Delineator reflectors shall be fastened to the posts with a vandal proof fastener approved by the Engineer.

The posts or brackets shall be vertical and oriented so that the face of the delineator shall be at 90 degrees to the centerline of the adjacent pavement.

Delineators shall be placed both as to lateral placement and height so as to have a satisfactory and uniform alignment. Acceptance of the delineator installation will include, in addition to ordinary inspection, a night inspection from an automobile by the Engineer and the Contractor, or a duly authorized representative. Delineators not having satisfactory and uniform night appearance shall be adjusted at the Contractor's expense until they do conform.

**635.05** Removing and Reinstalling Existing Delineator Posts and Reflectors. Existing delineator posts and reflectors shall be removed and reinstalled at the locations and spacings shown on the plans.

Removal shall be performed in a manner that will not cause any damage to the existing posts or reflectors. Any posts or reflectors damaged during the removal shall be replaced by the Contractor with the same type at his/her own expense. When necessary, the existing posts and reflectors shall be stored within the right of way in a manner approved by the Engineer prior to reinstallation.

Reinstallation of the posts and reflectors shall be according to the applicable requirements of Article 635.04. All damaged posts and reflectors shall be replaced with new posts and reflectors of the same type and color prior to reinstallation.

**635.06 Method of Measurement.** The work of installing new delineator posts and reflectors and of removing and reinstalling existing delineator post and reflectors will be measured for payment in place in units of each.

**635.07 Basis of Payment.** The work of furnishing and installing new delineator posts and reflectors will be paid for at the contract unit price each for DELINEATORS, which price shall include furnishing the posts, brackets, the reflector units and mounting hardware, erecting the posts, installing the brackets, fastening the reflector units to the posts or brackets, and all other items of work. No additional compensation will be allowed for 2 single reflector units placed back to back.

The work of removing and reinstalling existing delineator posts and reflectors will be paid for at the contract unit price each for REMOVE AND REINSTALL DELINEATORS, which price shall include replacing damaged posts and reflectors, except those damaged during removal and required to be replaced by the Contractor at his/her own expense.



# SECTION 636. CABLE ROAD GUARD

- **636.01 Description.** This work shall consist of constructing a cable road guard consisting of a steel cable mounted on posts.
- **636.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 Materials:

	Item	Article/Section
(a)	Cables and Accessories	1006.26
(b)	Wood Posts and Wood Block	1007.01, 1007.02, 1007.07
(c)	Steel Posts	1006.04
(d)	Preservative Treatment	1007.12
(e)	Portland Cement Concrete (Note 1)	1020
(f)	Reinforcement Bars	1006.10

Note 1: Concrete shall be Class SI Concrete.

#### **CONSTRUCTION REQUIREMENTS**

**636.03 General.** Cable road guard shall be constructed at the locations and according to the details shown on the plans. Either wood or steel posts shall be used at the option of the Contractor. The posts shall conform to the applicable paragraphs of Article 630.05.

End anchor arrangements shall be constructed at the ends of cable road guard. Dead end anchor arrangement shall be used when cable road guard is placed adjacent to a bridge or when conditions will not permit placing the post anchor beyond the end post. When the length of the cable road guard is more than 150 m (500 ft.), intermediate anchor arrangements shall be constructed at intervals not exceeding 150 m (500 ft.).

Cable splices will be permitted provided that no single piece of unspliced cable is less than 15 m (50 ft.). The cable shall be tensioned to the satisfaction of the Engineer.

**636.04 Method of Measurement.** Cable road guard will be measured for payment in meters (feet) in place from center to center of end posts.

**636.05 Basis of Payment.** This work will be paid for at the contract unit price per meter (foot) for CABLE ROAD GUARD, SINGLE STRAND, which price shall include the concrete, furnishing and installing dummy posts and all anchor arrangements.



# SECTION 637. CONCRETE BARRIER

- **637.01 Description.** This work shall consist of constructing a concrete barrier to the lines, grades and details shown on the plans.
- **637.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 Materials:

	Item	Article/Section
(a)	Portland Cement Concrete	1020
(b)	Welded Wire Fabric (Note 1)	1006.10
(c)	Anchor Bolts (Note 2)	1006.09
(d)	Preformed Expansion Joint Filler	1051.01, - 1051.08

Note 1. Fabric shall be 150 mm x 150 mm - 5.7 mm (6" x 6" - W4 x W4) weighing approximately 2.83 kg/m $^2$  (58 lbs. per 100 sq. ft.)

Note 2. Anchor bolts shall be Grade 60.

#### CONSTRUCTION REQUIREMENTS

**637.03 General.** Concrete Barrier shall be constructed according to the applicable provisions of Sections 503, 504, and 606.

The Contractor shall have the option of using precast or cast-in-place barrier, except that cast-in-place barrier shall be used when the slope of the surface in front of the barrier exceeds 4 percent.

When the slope of the surface in front of the barrier exceeds 4 percent, the axis of symmetry for the face of the barrier shall be vertical on the side where the surface slopes toward the barrier and shall be perpendicular to the surface on the side where the surface slopes away from the barrier.

When median lighting is specified, the lighting support section shall be cast-in-place. If precast units are being used, the precast units shall be placed prior to casting the lighting support section.

Where the horizontal alignment of the concrete barrier is curved, the barrier shall be constructed either on the curved alignment or on cords not more than 3 m (10 ft.) in length.

In lieu of welded wire fabric reinforcement in the concrete barrier, the Contractor may elect to use four No. 15 (No. 4) deformed horizontal reinforcement bars on 225-mm (9-inch) centers and No. 15 (No. 4) deformed vertical reinforcement bars on 750-mm (2'- 6") centers. (The vertical bars may be omitted if the wall is slip formed.) The reinforcement bars shall be lapped a minimum of 325 mm (13").

Precast units shall not be removed from the casting beds until a flexural strength

of not less than 2 MPa (300 psi) or a compressive strength of not less than 10 MPa (1400 psi) is attained. Transportation of precast sections to the jobsite will not be allowed until a flexural strength of not less than 4.5 MPa (650 psi) or a compressive strength of not less than 24 MPa (3,500 psi) is attained. In no case may precast units be loaded, shipped and used prior to 4 days after casting.

All precast units shall be firmly butted together in a smooth continuous line.

In the transition section of the precast median barriers, the space between the two single faced sections shall be filled with concrete or subbase granular material, Type C. The cost of the fill shall be included in the pay items for the barrier.

When the transition section between single face and double face barrier is used, the shear groove shall be completely filled with grout as directed by the Engineer after the barrier is in place.

**637.04 Slipforming.** When slip form methods are used, the machine shall be approved by the Engineer. The dimensions of the barrier shall be within the tolerances shown on the plans. Barriers having dimensions outside the tolerance limits will be rejected and shall be removed and replaced. The vertical centerline of the barrier shall not vary from the proposed centerline alignment by more than 75 mm (3 inches) nor by more than 13 mm (1/2 inch) in 3 m (10 ft.). In addition, all surfaces shall be checked with a 3-m (10-ft.) straightedge furnished and used by the Contractor as the concrete is extended from the slipform paver.

Barriers having surface irregularities greater than 10 mm (3/8 inch) in 3 m (10 ft.) shall be corrected immediately at the Contractor's expense. Continued variations in the barrier surface exceeding 6 mm (1/4 inch) in 3 m (10 ft.) will not be permitted and remedial action shall immediately be taken to correct the problem. Any deformations or bulges remaining after the initial set shall be removed by grinding after the concrete has hardened. The vertical surface at the base of the barrier shall be trowelled true after passage of the slip form machine. All holes and honeycomb shall be patched immediately. The entire surface shall receive a light brush finish before final set.

- **637.05 Finishing.** The surface of concrete barriers shall be finished as specified in Article 503.16 (a).
- **637.06 Securing Barrier to Base.** Dowel bars used to secure concrete barrier to the base shall be No. 25 (No. 8) deformed reinforcement bars of a length necessary to obtain the minimum embedment shown on the plans. Dowel bars placed in existing portland cement concrete pavement or existing paved median surface shall be set in mortar in drilled holes to the satisfaction of the Engineer.

Precast barrier shall be either dowelled in place or placed on a grout bed. When dowel bars are used, the barrier shall be placed on a bed of dry cement not exceeding 13 mm (1/2 inch) in thickness to achieve proper alignment and seating. Three dowels shall be placed in each precast barrier section. For double face barrier, the dowels shall be staggered side to side. All dowel holes and lifting holes or slots shall be grouted closed to the satisfaction of the Engineer unless otherwise required for drainage of backfill material for single face barrier. When a grout bed is used, the grout shall be placed such that after seating the barrier the grout thickness will be approximately 13 mm (1/2 inch) thick and the continuous shear key will be composed of

1 part portland cement to 2 parts fine aggregate.

For cast-in-place barriers, dowel bars shall be on 1.2-m (4'-0") centers and staggered side to side except when a polyethylene bond breaker is used. Dowel bars may be eliminated for new rigid base when the barrier is cast integrally with the base. A 50 mm x 150 mm (2" x 6") key way may be cast into new rigid base and used in lieu of dowels.

**637.07 Joints.** Expansion joints shall be installed in the concrete barrier in prolongation with expansion joints in the adjacent concrete pavement or shoulder and shall be similar in opening to the type of joint adjoining it.

At locations where precast or cast-in-place concrete barrier abuts a rigid structure, a 50-mm (2-inch) thick preformed expansion joint filler conforming to the shape of the barrier shall be installed between the barrier and the structure. Concrete nails or other suitable methods shall be used to hold the expansion joint filler in place.

For cast-in-place barriers, construction joints shall be formed with the use of a smooth header and the reinforcement shall be continuous through the joint. Contraction joints shall be installed at existing contraction or hinge joints in the concrete pavement or shoulder and at uniform intervals with a maximum spacing of 6 m (20 ft.). Contraction joints shall be formed by a groove 3 mm (1/8 inch) wide by 50 mm (2 inches) deep either formed in the plastic concrete or sawed after the concrete has set. The reinforcement shall be continuous through all contraction joints.

#### 637.08 Method of Measurement.

- (a) Contract Quantities. The requirements for the use of Contract Quantities shall conform to Article 202.07(a).
- (b) Measured Quantities. Concrete barrier, single face, and concrete barrier, double face, will be measured for payment in meters (feet) in place, along the centerline of the barrier. The length measured for payment will be the overall length to the limits shown on the plans. Transitions in width from double to single face barrier will be included in the overall length measured for Concrete Barrier, Double Face. The Lighting Support Section will be included in the overall length measured for Concrete Barrier, Double Face. The foundation portion under the Lighting Support Section will not be measured for payment.
- **637.09** Basis of Payment. This work will be paid for at the contract unit price per meter (foot) for CONCRETE BARRIER, DOUBLE FACE or CONCRETE BARRIER, SINGLE FACE.



# **SECTION 638. GLARE SCREEN**

- **638.01 Description.** This work shall consist of constructing glare screens consisting of concrete glare screen, glare screen blades, or modular glare screen blades, mounted on concrete medians.
- **638.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 Materials:

	Item	Article/Section
(a)	Glare Screen Blades	1086
(b)	Portland Cement Concrete (Note 1)	1020
(c)	Reinforcement Bars	1006.10
(d)	Modular Glare Screen Blades	1086

Note 1. Concrete shall be Class SI Concrete.

#### **CONSTRUCTION REQUIREMENTS**

**638.03 Glare Screen Blades.** Glare screen blades and modular glare screen blades shall be installed on the concrete barrier according to the details shown on the plans or as directed by the Engineer. Base plate brackets or modules shall be placed true to line and at the spacing and angles shown on the plans. Anchor studs shall be at least 75 mm (3 inches) from any contraction, expansion, or construction joint in the barrier. Base plates shall be firmly attached to the concrete barrier with 2 expansion anchor studs. Modules shall be firmly attached to the concrete barrier with 6 expansion anchor studs. Anchor studs shall be secured by tightening the nuts with 34 to 40 N·m (25 to 30 ft.-lbs.) of torque.

The Contractor shall load test 4 percent of all anchor studs in the presence of the Engineer. The equipment and method used shall meet the approval of the Engineer. The minimum test load shall be 18 kN (4000 lbs.) in direct pull. For each anchor that fails the test requirement, 2 more anchor studs, picked by the Engineer, shall be tested. Each anchor stud that fails to meet the test requirement shall be reset, or removed and the hole drilled deeper and reset, and retested until it meets the test requirements.

Glare screen blades shall be placed on the base plate brackets true to line. When in final position, self-tapping screws shall be installed snug against the plastic surface without exceeding a maximum torque of 20 N·m (15 ft.-lbs.).

Unless otherwise directed by the Engineer, all construction operations shall be performed on one side of the concrete median barrier. Any damage done to the concrete barrier by the Contractor's operation shall be repaired by and at the expense of the Contractor to the satisfaction of the Engineer.

**638.04** Concrete Glare Screen. Concrete glare screen shall be constructed according to the applicable requirements of Section 637.

When concrete glare screen is constructed on an existing concrete barrier, the vertical reinforcement bars shall be grouted in place in drilled holes in the barrier to the satisfaction of the Engineer. Joints in the concrete glare screen shall be a continuation of joints in the existing concrete barrier and shall be of the same configurations. In addition, if there is a crack in the barrier that is working as a joint, a joint shall be placed over it in the glare screen and the reinforcement shall be cut.

When concrete glare screen is constructed on new concrete barrier, it may be constructed integrally with the barrier. Joints in the glare screen shall be as specified in Article 637.07.

**638.05 Method of Measurement.** The various heights of glare screen blades will be measured for payment in units of each blade complete in place.

Concrete glare screen will be measured for payment in meters (feet) in place, measured along the centerline of the concrete glare screen.

Modular blade-type glare screen will be measured for payment in meters (feet) in place, measured along the centerline of the modular blade-type screen.

**638.06 Basis of Payment.** Glare screen blades will be paid for at the contract unit price each for GLARE SCREEN BLADES, of the height specified.

Modular blade-type glare screens will be paid at the contract unit price per meter (foot) for MODULAR BLADE-TYPE GLARE SCREENS.

The work of constructing concrete glare screen will be paid for at the contract unit price per meter (foot) for CONCRETE GLARE SCREEN.



## SECTION 639. PRECAST PRESTRESSED CONCRETE SIGHT SCREEN

**639.01 Description.** This work shall consist of furnishing and installing a precast prestressed concrete panel wall sight screen.

**639.02 Materials.** Materials shall be according to the following Articles of Section 1000:

	Item	Article/Section
(a)	Galvanized Steel plates (Note 1)	1006.04
(b)	Galvanized Bolts and Washers	1006.27(f)
(c)	Prestressing Steel (Note 2)	1006.10(d)
		1004

Note 1: Threaded inserts shall be galvanized steel capable of developing the shear strength of the bolts by which they are engaged and shall be approved by the Engineer.

Note 2: The steel shall be Grade 270, have a diameter of 10 mm (3/8 inch) and have a minimum cross sectional area of 55 mm<sup>2</sup> (0.085 sg. inches).

#### CONSTRUCTION REQUIREMENTS

- **639.03 General.** The sight screen shall be as shown on the plans and according to AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, Traffic Signals, and AASHTO Standard Specifications for Highway Bridges. The earth upon which the base of each panel rests shall be firm and level for the entire width of the panel. Excavated material which is clean and free of organic content, or sand, may be used to even out deviations from the horizontal grade at the bottom of the excavation. The bottom of the excavation shall be compacted sufficiently to prevent unequal settlement of the panels as they are set in place.
- **639.04** Backfill. Backfill shall be coarse aggregate and shall be thoroughly compacted around the base of the wall using a mechanical tamper approved by the Engineer.

- **639.05 Lifting Devices.** The type, number, and locations of lifting devices and the method of handling the precast prestressed panels shall be determined by the fabricator and approved by the Engineer. Portions of the lifting devices which project beyond the surface of the panel shall be sawed or burned off after erection. Lifting devices shall not be located in the surface of the panel facing toward the road.
- **639.06 Fabrication.** The fabrication of the precast prestressed panels shall be according to the applicable requirements of Section 504 except for the following:
  - (a) The minimum 28 day compressive strength, and the strength at the time of transfer of prestress, of the concrete, shall be 24.1 MPa (3,500 psi) and 15.5 MPa (2,250 psi), respectively.
  - (b) One standard 150 x 300 mm (6 x 12 inch) test cylinder shall be made for each 1.5 m<sup>3</sup> (2 cu. yds.) of concrete used in the panels, with a minimum of 6 cylinders to be made from the concrete used to fabricate the panels on each prestressing bed.
- **639.07 Method of Measurement.** The concrete wall will be measured for payment in meters (feet). The overall length will be measured along the longitudinal axis of the wall from the extreme ends of the end panels.
- **639.08** Basis of Payment. This work will be paid for at the contract unit price per meter (foot) for SIGHT SCREEN (PRECAST PRESTRESSED CONCRETE PANEL WALL), of the height specified.



#### SECTION 640. CHAIN LINK FENCE SIGHT SCREEN

- **640.01 Description.** This work shall consist of furnishing and installing a chain link fence sight screen.
- **640.02 Materials.** The steel posts shall be galvanized according to ASTM A 53. Structural steel tubing shall be according to ASTM A 501 and shall be galvanized according to AASHTO M 111. Fabric ties, fittings, bolts, nuts, and all other hardware shall conform to the applicable requirements of Article 1006.27.

The top and middle brace rails shall be steel pipe 41 mm (1 5/8 inch) outside diameter, mass (weight) of 3.30 kg/m (2.27 lbs/ft.) and galvanized according to ASTM A 53.

Wood privacy slats shall be 8 mm or 10 mm x 60 mm (5/16 inch or 3/8 inch x 2 3/8 inch) and shall be factory installed. The slats shall be untreated redwood or cedar or treated timber of an approved alternate treated according to Article 1007.12. The slats shall be sound without decay or rot, containing no knot holes larger than one-half the width of the slat.

Steel chain link fabric shall be zinc-coated steel fabric or aluminum-coated steel fabric according to Article 1006.27. The fabric shall be 3.76 mm (#9) gage wire woven in 89 mm x 125 mm (3 1/2 inch x 5 inch) mesh with the top and bottom selvages knuckled.

Zinc-coated or aluminum-coated metal slats of 0.5 mm (#26 gage) steel strip, 70 mm (2 3/4 inch) minimum width, shall be inserted into the chain link fabric, as shown

on the plans, after the fabric is mounted against the posts. The zinc coating shall be according to ASTM A 525M (A 525) coating designation G 90. The aluminum coating shall conform to ASTM A 463 coating desgination TI 40. The coating on the slats shall be the same type as on the fabric.

Chain link fabric shall be attached to pull posts using minimum 6 x 20 mm (1/4 inch x 3/4 inch) flat stretcher bars and 2.69 mm (#12 gage) by 25 mm (1 inch) wide stretcher bar bands with 10 mm (3/8 inch) diameter carriage bolts. Stretcher bars, stretcher bar bands, and carriage bolts shall be according to Article 1006.27.

Tension cable shall be 10 mm (3/8 inch) diameter, 1 x 7 steel strand with 48 kN (10,800 lbs.) minimum breaking strength according to ASTM A 475 with Class B galvanized coating. Cable clamps and turnbuckles for use with tension cable shall be galvanized steel, be adequate to develop the full strength of the cable, and be approved by the Engineer.

Truss rods shall be 10 mm (3/8 inch) diameter and be provided with turnbuckles or some other suitable means of adjustment, and conform to Article 1006.26(c).

### **CONSTRUCTION REQUIREMENTS**

**640.03 General.** The sight screen shall be as shown on the plans and according to AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals.

Pull posts shall be spaced as follows:

- (a) 70 m (240 feet) maximum centers for 1.8 m (6 ft.) fence
- (b) 60 m (200 ft.) maximum centers for 2.4 m (8 ft.) fence
- (c) 48 m (160 ft.) maximum centers for 3.0 m (10 ft.) fence

All posts shall be set in foundations of Class SI concrete of the depth and diameter shown on the plans.

Chain link fence construction shall be according to Section 664.

The chain link fabric shall be installed on the side of the posts facing toward the road, so the line posts and brace rails are hidden from the view of passing motorists.

**640.04 Grounding.** Continuous fence shall be grounded at intervals not exceeding 150 m (500 ft.) in urban areas and 300 m (1,000 ft.) in rural areas.

Fence under a power line shall be grounded by 3 grounds, one directly under the crossing and one on each side, 7.5 to 15 m (25 to 50 ft.) away. A single ground shall be located directly under each telephone wire or cable crossing.

The ground wire shall be connected to the fabric and the ground rod by a mechanical clamp of a cast bronze body and bronze or stainless steel bolts and washers. The bottom connection of the ground wire shall be made to the tension cable.

**640.05 Method of Measurement.** Chain link fence sight screen will be measured for payment in meters (feet), along the top of the fence from center to center of the end posts.

**640.06 Basis of Payment.** This work will be paid for at the contract unit price per meter (foot) for SIGHT SCREEN (CHAIN LINK FENCE) of the height specified.



### SECTION 641. WOOD FENCE SIGHT SCREEN

**641.01 Description.** This work shall consist of furnishing and installing wood fence sight screen.

**641.02 Materials.** Bolts and washers shall be according to Article 1006.17.

Nails shall be galvanized common wire nails.

All lumber shall be sound and free from excessive splitting or deterioration. Dimensions shown on the plans are for surfaced (S4S) lumber. Rough sawn lumber of the nominal size shown may be used for any members provided it can be successfully stress graded and pieces of the same nominal size are sawn to a uniform width and thickness.

The required grade of lumber is visually stress graded according to the rules of the following agencies:

- (a) Douglas Fir & Western Red Cedar West Coast Lumber Inspection Bureau
- (b) Southern Pine-Southern Pine Inspection Bureau
- (c) Red (Swamp) Cypress-National Hardwood Lumber Association

The grades shown below in the table are the minimum acceptable and all species shown are alternates for the indicated usage.

All wood, except Red (Swamp) Cypress and Western Red Cedar, used for posts, rails, or planks, shall be treated with ACA or CCA as specified in Article 1007.12 except the retention shall be specified in the following table:

Fence Height	Usage mm (inches)	Lumber Species	Commercial Grade	Preservative Retention kg/m <sup>3</sup> (lbs./cu. ft.)
1.8 m (6 ft.)	Rails 75 x 100 (3 x 4)	Douglas Fir Southern Pine	No. 2 No. 1/D	6.41 (0.40) 6.41 (0.40)
or	Posts 150 x 200 (6 x 8) or	Douglas Fir	No. 2	9.61 (0.60)
2.4 m (8 ft.)	200 x 200 (8 x 8)	Southern Pine	No. 1/D	9.61 (0.60)
	Planks	Red (Swamp) Cypress Southern Pine Western Red Cedar	No. 2 No. 1/D No. 1 Fencing	NA 6.41 (0.40) NA

#### CONSTRUCTION REQUIREMENTS

**641.03 General.** The sight screen shall be as shown on the plans and according to AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaire and Traffic Signals, AASHTO Standard Specifications for Highway Bridges. Wooden fence construction shall conform to the applicable requirements of Section 507.

All fencing for any one installation shall be of the Wood Plank, Type P, or the Cedar Stockade, Type S. The two types shall not be mixed together.

Cedar pickets shall be either split or round, be completely stripped of bark, and be straight and free of excessive taper or bowing, and when installed, shall butt tightly against one another. There shall be no gaps greater than 6 mm (1/4 inch) in width between adjacent pickets.

Fence panels, consisting of horizontal rails and wood planks or cedar pickets, may be prefabricated or built in place. Additional nails, not shown on the plans, may be used to temporarily tack members in place during erection.

Nailing shall be done in such a manner as to avoid splitting the lumber. Lumber which, in the opinion of the Engineer, is split excessively, will be rejected.

- **641.04 Backfill.** The backfill for posts shall be CA 6, CA 10, or CA 12 aggregate according to Article 1004.01. Backfill shall be thoroughly compacted, meeting the approval of the Engineer.
- **641.05 Method of Measurement.** Wooden fence will be measured for payment in meter (feet), along the top of the fence from center to center of end posts.

**641.06** Basis of Payment. This work will be paid for at the contract unit price per meters (foot) for SIGHT SCREEN (WOODEN FENCE), of the type and height specified.

#### OTHER ITEMS

#### **SECTION 660. RESERVED**

#### SECTION 661. BITUMINOUS SHOULDER CURB

- **661.01 Description.** This work shall consist of the construction of bituminous curb along the outer edge of bituminous shoulders.
- **661.02 Materials.** All materials shall meet the requirements of Article 406.02 with the following exceptions:
  - (a) Only Class I Surface mixtures C or D shall be used.
  - (b) Composition limits by weight shall be as follows:

	Passing	12.5 mm (1/2") sieve, ret'd 2.0 mm (No. 10) sieve	20-70%
	Passing	20 mm (No. 10) sieve, ret'd 75 $\mu$ m (No. 200) sieve	20-48%
	Passing	20 mm (No. 10) sieve, ret'd 75 $\mu$ m (No. 200) sieve 75 $\mu$ m (No. 200) sieve	3-9%
_			3.5-9%

Note 1. The bituminous material shall be AC-10 or AC-20 as directed by the Engineer.

#### CONSTRUCTION REQUIREMENTS

**661.03 General.** The temperature of the base on which the curb is placed shall not be less than 4 °C (40 °F.) at the time the curb is placed. Prior to placing the curb, the base shall be cleaned and then primed with bituminous material selected from the table in Article 406.02 at a rate of 0.2 to 0.5 L/m<sup>2</sup> (0.05 to 0.1 gal. per sq. yd.).

The bituminous shoulder curb shall be constructed with a mechanical curb laying machine of a type approved by the Engineer. Prior to constructing the curb, additional shoulder shall be constructed according to the details shown on the plans. After the curb is constructed, a liberal application of asphalt seal coat shall be applied uniformly to all exposed curb surfaces by spraying or brushing at a rate satisfactory to the Engineer. The seal coat may be any emulsified asphalt, asphalt cement, rapid curing cutback asphalt, or medium curing cutback asphalt.

- **661.04 Method of Measurement.** The bituminous shoulder curb will be measured for payment in meters (feet) along the face of the curb in place. No deduction in length will be made for any drainage structures installed in the curbing.
- **661.05** Basis of Payment. This work will be paid for at the contract unit price per meter (foot) for BITUMINOUS SHOULDER CURB, which price shall include the additional shoulder under the curb, priming the base prior to placement and sealing the curb after completion.

#### SECTION 662. CONCRETE SHOULDER CURB

- **662.01 Description.** This work shall consist of the construction of concrete curb along the outer edge of portland cement concrete shoulders.
- **662.02 Materials.** Materials shall be according to the following Articles of Section 1000 Materials:

	Item	Article/Section
(a)	Portland Cement Concrete (Note 1)	1020
(b)	Protective Coat	1023.01
(c)	Poured Joint Sealer	1050

Note 1. Concrete shall be Class SH Concrete.

#### CONSTRUCTION REQUIREMENTS

- **662.03 General.** Concrete shoulder curb shall be constructed according to the details shown on the plans and the applicable requirements of Section 483. The concrete shoulder curb shall be constructed integrally with the portland cement concrete shoulder. Joints in the shoulder shall be continued through the curb and shall be sealed as specified in Article 483.07.
- **662.04 Method of Measurement.** Concrete shoulder curb will be measured for payment in meters (feet) in place along the face of the curb. No deduction in length will be made, for any drainage structures installed in the curb.

Protective coat, if required, will not be measured for payment.

**662.05 Basis of Payment.** This work will be paid for at the contract unit price per meter (foot) for CONCRETE SHOULDER CURB, which price shall include sawing and sealing the joints and applying the protective coat when required.

#### **SECTION 663. CALCIUM CHLORIDE APPLIED**

- **663.01 Description.** This work shall consist of furnishing and applying calcium chloride.
- **663.02 Materials.** Materials shall be according to the following Article of Section 1000 Materials:

	Item	Article	e/Section
(a)	Calcium Chloride		1013.01

Calcium chloride may be Type S (solid) or Type L (liquid). Type S may be Grade 1 (77%), Grade 2 (90%), or Grade 3 (94%). Type L may have anhydrous chloride contents of 30 to 45%.

#### CONSTRUCTION REQUIREMENTS

- **663.03 General.** The rate of application per square meter (square yard) and the quantity shown in the contract is based on the amount of anhydrous chloride to be applied. The actual application rate shall be the rate shown in the contract divided by the decimal equivalent of the percent anhydrous chloride.
- **663.04 Method of Measurement.** Calcium Chloride Applied will be measured for payment by mass (weight) in metric tons (tons).

The quantity of calcium chloride for which payment will be made will be the total mass (weight) multiplied by the decimal equivalent of the percent of anhydrous chloride.

**663.05 Basis of Payment.** This work will be paid for at the contract unit price per metric ton (ton) for CALCIUM CHLORIDE APPLIED.

When it is specified that the calcium chloride is to be mixed with aggregate, the cost of mixing shall be included in the type of work performed.



### **SECTION 664. CHAIN LINK FENCE**

- **664.01 Description.** This work shall consist of constructing a chain link fence.
- **664.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 Materials:

	Item	Article/Section
(a)	Chain-Link Fabric	1006.27
(b)	Line Posts (Steel Pipe, Structural Shapes and	
	Roll Formed Sections)	1006.27
(c)	Terminal Posts (End, Corner or Pull)	1006.27
(d)	Gate Posts	1006.27
(e)	Tension Wire	1006.27
(f)	Horizontal Braces	1006.27
(g)	Truss Rods	1006.26
(h)	Gate Frames	1006.27
(i)	Post Tops	1006.28
(j)	Stretcher Bars (Note 1)	
(k)	Fabric Ties	1006.27
(I)	Fittings	1006.27
(m)	Bolts and Nuts	1006.27
(n)	Barbed Wire	1006.28

Note 1. Stretcher bars shall be galvanized flat steel bar not less than 6 mm x 19 mm (1/4 inch x 3/4 inch) and the stretcher bar bands shall be galvanized flat steel bar not less than 3 mm x 25 mm (1/8 inch x 1 inch) with an M10 (3/8 inch) galvanized carriage bolt.

#### CONSTRUCTION REQUIREMENTS

- **664.03 General.** At locations of small natural or drainage ditches where it is not practical to conform the fence to the general contour of the ground surface, the Contractor, when directed, shall span the opening below the fence with barbed wire fastened to stakes of such length as required. The new fence shall be permanently tied to the terminals of existing fences whenever required by the Engineer. The finished fence shall be plumb, taut, true to line and ground contour, and complete in every detail. Where directed, the Contractor will be required to stake down the chain link fence at several points between posts.
- **664.04 Installing Posts.** Posts shall be properly spaced and set in Class SI Concrete conforming to the applicable portions of Section 1020 except if the concrete is mixed in transit mixers or transported in agitating trucks, the time limit for unloading it may be extended to 120 minutes by the Engineer. Wherever right of way markers are omitted, the posts shall be set with back of post flush with the right of way line.

On terminal (end, corner, pull, brace) and gate posts, the post tops where required and brace rail clamps around the posts shall be placed before setting the posts in concrete bases. In setting the gate posts, great care shall be taken to make sure that gate posts are set the exact distance apart as shown on the plans. A line drawn across from the top of one gate post to the other shall be level, regardless of the grade at the ground line. If the ground is not level, the upgrade post shall be set first to get the proper height for the downgrade post. Fence shall not be erected until the concrete encasement around the posts has cured for at least 7 days. Stretcher bar bands and truss bands as called for on the plans shall be spread and slipped on end, corner, pull, brace and gate posts as the next operation. Post tops shall then be installed on all other posts where required.

- **664.05 Post Tops.** All hollow pipe and tube type posts shall be fitted with post tops. The bases of the post tops shall have flanges which fit around the outside of the posts and shall be secured in place.
- **664.06 Tension Wire.** Tension wires shall be used in the erection of chain link fence. The top and bottom tension wire shall be placed, stretched taut, and secured at ends to all posts in a satisfactory manner before fabric is placed. Tension wire shall be stretched tight with galvanized turn buckles spaced at intervals of not more than 300 m (1000 ft.).
- **664.07 Braces.** When required by the plans, braces shall be placed 300 mm (12 inches) down from the top of the terminal posts and shall extend from the terminal (end, corner and pull) posts and gate posts to the brace posts. The braces shall be securely fastened to the post and trussed from brace post back to terminal posts with 10 mm (3/8-inch) round rods with a turnbuckle.
- **664.08 Fabric.** The fabric shall be unrolled on the outside of the fence line with the bottom edge of the fabric against the posts. The various rolls shall be spliced by bringing the ends close together and weaving in a picket in such a way that it will engage both of the roll ends and catch with each twist each separate mesh of the end pickets of both rolls of fabric.

At end, corner or gate posts, the stretcher bar shall be slipped through the end picket of the fabric and the stretcher bar bands at the same time. Then the bolts in

the stretcher bar bands shall be tightened. Additional rolls of fabric shall be spliced and placed as the erection progresses along the fence. In long sections, the fence shall be stretched at intervals of about 30 m (100 ft.). The fabric shall be placed by securing one end and applying sufficient tension to remove all slack before making attachments elsewhere. After the fabric has been stretched, it shall be tied to the tension wire with fabric ties spaced not more than 600 mm (24 inches) apart. The fabric shall then be attached to the line posts with fabric ties spaced not more than 355 mm (14 inches) apart. The topmost clip shall be placed on the line post as near the top of the fabric as possible and the lowest clip as near the bottom of the fabric as possible. At terminal (end, corner and pull) and gate posts, the fabric shall be fastened with stretcher bars and bands. The fastenings shall be spaced not more than 355 mm (14 inches) on centers for terminal (end, corner and pull) and gate posts. The topmost band shall be placed on these posts as near the top of the fabric as possible and the lowest band as near the bottom as possible.

Standard chain link fence stretching equipment shall be provided for stretching the fabric before tying it to the tension wire and posts. The stretching and tying operations shall be repeated about every 30 m (100 ft.) until the run of fence is completed.

Before making a closure, the other end of the run shall be fastened to the end, corner or gate post as described previously. The operation of making a closure of a run shall be as follows: The stretching equipment shall be clamped on the ends of the fabric parallel to each other and about 1.5 m (5 ft.) apart when the tension is first applied. The stretching shall continue until the slack has been removed from both sections of the fabric. If the ends overlap, the fabric shall be cut to match. The ends shall be joined by the insertion of a picket similar to the methods of connecting 2 rolls of fabric.

- **664.09 Gates.** The gates shall be hung on gate fittings as shown on the plans. The lower hinge (ball and socket type) shall be placed on top of the concrete in which the gate post is set. The sockets for the cane or foot bolts shall be set in concrete so that the plunger pin will fit perfectly in the socket when the gate is in a closed position. Gates shall be so erected as to swing in the direction indicated and shall be provided with gate stops as specified or shown on the plans. Gate keepers shall be provided to hold gates when in open position, and shall be located and installed as directed by the Engineer. Gates shall be erected in suitable places as directed by the Engineer or as shown on the plans. All hardware shall be thoroughly secured, properly adjusted and left in perfect working order. Hinges and diagonal bracing in gates shall be adjusted so that gates will hang level.
- **664.10 Existing Fence Connections.** Wherever a new fence joins an existing fence, either at a corner or at the intersection of straight line fences, a corner post with brace post shall be set at the junction and braced the same as described for corner posts or as shown on the plans.

If the connection is made at other than the corner of the new fence, the last span of the old fence shall contain a brace span.

**664.11** Protective Electrical Ground. Continuous fence shall be grounded at intervals not exceeding 150 m (500 ft.) in urban areas and 300 m (1000 ft.) in rural areas. There shall be a ground within 30 m (100 ft.) of gates in each section of the fence adjacent to the gate.

Fence under a power line shall be grounded by three grounds, one directly under the crossing and one on each side 7.5 m (25 ft.) to 15.0 m (50 ft.) away. A single ground shall be located directly under each telephone wire or cable crossing.

The counterpoise ground shall be used only where it is impossible to drive a ground rod.

The ground wire shall be connected to the fabric and the ground rod by a mechanical clamp of cast bronze body and bronze or stainless steel bolts and washers.

- **664.12 Method of Measurement.** Chain Link Fence will be measured for payment in meters (feet), along the top of the fence from center to center of end posts, excluding the length occupied by gates.
- **664.13 Basis of Payment.** This work will be paid for at the contract unit price per meter (foot) for CHAIN LINK FENCE, and at the contract unit price each for CHAIN LINK GATES, of the opening sizes and types specified, which prices shall include payment for all excavation and backfilling except excavation in rock which will be paid for according to Section 502 for Rock Excavation for Structures.

The contract unit price for Chain Link Fence shall also include furnishing all materials and installing the complete fence, except gate posts, gates, fittings and accessories for the gates, and shall include clearing, encasing the posts with concrete, and furnishing and installing protective electrical grounds.

The contract unit price for Chain Link Gates shall also include furnishing all materials and installing the complete gates including the gate posts and fittings and accessories for the gates and gate posts, and clearing and encasing the posts with concrete.



# **SECTION 665. WOVEN WIRE FENCE**

- **665.01 Description.** This work shall consist of constructing a combination woven wire and barbed wire fencing supported on either wood or metal posts, including gates and accessories.
- **665.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 Materials:

	Item	Article/Section
(a)	Woven Wire Fencing	1006.28
(b)	Barbed Wire	
(c)	Wood Posts	1007.11
(d)	Wood Braces and Blocks	1007.11
(e)	Brace Wires	1006.28
(f)	Metal Posts	1006.28
(g)	Metal Braces	1006.28
(h)	Gate Frames	1006.28
(i)	Fittings and Miscellaneous Materials	1006.28
(j)	Bolts and Nuts	1006.27

#### CONSTRUCTION REQUIREMENTS

**665.03 General.** Posts shall be set vertical and in true alignment. The new fence shall be permanently tied to the terminals of existing fences when required by the Engineer.

Metal corner, end, pull posts and braces shall be properly spaced and set in Class SI Concrete conforming to the applicable portions of Section 1020, except that if the concrete is mixed in transit mixers or transported in agitator trucks, the time limit for unloading it may be extended to 120 minutes by the Engineer. Metal line posts may be driven in place.

All wood posts shall be set according to Article 634.05.

Any high points which interfere with the placing of woven wire shall be graded to provide the clearance shown on the plans.

Barbed and woven wire shall be pulled tight, according to standard practice and the recommendations of the manufacturer, and shall be fastened to wood posts by means of 40 mm (1 1/2 inch) minimum galvanized fence staples and to metal posts by means of wire, clips or other suitable fasteners. Splicing barbed or woven wire shall be accomplished by using either a wrapped splice or a corrosive resistant, compressed sleeve type splice meeting the approval of the Engineer. When a wrapped splice is used for woven wire, the vertical wires adjacent to the ends shall be brought together and the end of each horizontal wire wrapped not less than 6 complete turns around the other corresponding horizontal wire. When barbed wire is spliced, each end shall be wrapped not less than 6 complete turns around the other wire.

Gates shall be assembled and installed according to the details shown on the plans. Vehicle gates shall swing open 180°. Pedestrian gates shall swing open 90°. Gate keepers shall be provided to hold gates when in an open position and shall be located and installed as directed by the Engineer.

Continuous fence shall be grounded at intervals not exceeding 60 m (200 ft.). There shall be a ground not exceeding 10.7 m (35 ft.) from a gate in each section of the fence adjacent to a gate. There shall be a minimum of one ground in any partial section of fence, constructed separately but in conjunction with main fence.

Fence under a power line shall be grounded by three grounds, one directly under the crossing and one on each side 8 m (25 ft.) to 10.7 m (35 ft.) away. A single ground shall be placed directly under each telephone wire or cable crossing. Each barbed wire and the top and bottom wires of the woven fence shall be fastened to the metal post by a mechanical means to assure a tight connection for positive grounding. When metal line posts are used in lieu of wood line posts, this grounding is not required.

- **665.04 Method of Measurement.** Woven wire fence will be measured for payment in meters (feet) along the top of the fence from center to center of end posts, excluding the length occupied by gates.
- 665.05 Basis of Payment. This work will be paid for at the contract unit price per meter (foot) for WOVEN WIRE FENCE, and at the contract unit price each for WOVEN WIRE GATES, of the sizes and types specified, which prices shall include all excavation and backfilling, except excavation in rock which will be paid for

according to Section 502 for Rock Excavation for Structures.

The contract unit price for woven wire fence shall also include furnishing and installing the complete fence except gate posts, gates, and fittings and accessories for the gate, and for clearing, encasing the posts with concrete, and furnishing and installing protective electrical grounds.

The contract unit price for Woven Wire Gates shall also include furnishing and installing the complete gates including the gate posts and fittings and accessories for the gates and gate posts, and clearing and encasing the posts with concrete.



# **SECTION 666. RIGHT OF WAY MARKERS**

- **666.01 Description.** This work shall consist of furnishing and erecting concrete right of way markers, or removing and reerecting right of way markers.
- **666.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 Materials:

	Item	Article/Section
(a)	Portland Cement Concrete	1020
(b)	Reinforcement Bars	1006.10

#### **CONSTRUCTION REQUIREMENTS**

**666.03 Furnishing and Erecting.** Right of way markers shall be precast of Class SI Concrete according to the designs shown on the plans.

Right of way markers shall not be erected within the corporate limits of cities, villages or towns. When erected within improved residential areas, Method B right of way markers shall be used. Method A right of way markers shall be used at all other locations as shown on the plans.

Right of way markers shall be set so the back of the post is flush with the right of way line, except when the marker conflicts with a property pin, in which case the right of way marker shall be offset. The markers shall be set in compacted soil, and the bottom of the holes shall be rammed to provide a stable foundation. They shall be set in a vertical position with the lettered side facing the roadbed. The holes shall be backfilled and thoroughly compacted with approved materials in layers in such manner that the bottom of the markers will remain in the correct position.

Right of way markers shall be erected before any grading operations are started, except that markers in easement areas may be erected after the final grading is complete.

**666.04** Removing and Reerecting. Existing right of way markers designated to be removed and reerected shall be removed in a manner that will not damage the marker. Any marker damaged during removal shall be replaced with a new marker by the Contractor at his/her expense. Holes shall be backfilled as directed by the Engineer.

The existing right of way markers shall be reerected at the locations shown on the plans. Reerecting of existing right of way markers shall be as specified above in Article 666.03. Existing markers damaged during removal or otherwise considered unsatisfactory for reuse shall be replaced with new markers before reerecting.

**666.05 Basis of Payment.** Furnishing and erecting right of way markers will be paid for at the contract unit price each for FURNISHING AND ERECTING RIGHT OF WAY MARKERS, which price shall include furnishing the markers and of all excavation and backfill, except excavation in rock.

The work of removing and reerecting existing right of way markers will be paid for at the contract unit price each for REERECTING RIGHT OF WAY MARKERS, which price shall include removing the existing markers, replacing unsatisfactory markers with new markers except those damaged during removal and required to be replaced by the Contractor at his/her own expense, and all excavation and backfill except excavation in rock.

Excavation in rock will be paid for as specified in Section 502 for Rock Excavation for structures.



### SECTION 667. DRAINAGE MARKERS AND PERMANENT SURVEY MARKERS

- **667.01 Description.** This work shall consist of furnishing and erecting drainage markers or furnishing and installing permanent survey markers.
- **667.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 Materials:

#### **CONSTRUCTION REQUIREMENTS**

**667.03 Drainage Markers.** Drainage markers shall be precast of Class SI Concrete according to the design shown on the plans.

Drainage markers shall be placed at the right of way line at the locations shown on the plans or where directed by the Engineer. They shall be erected according to the requirements of Article 666.03. The reference in Article 666.03 to right of way markers shall be construed to include drainage markers.

**667.04 Permanent Survey Markers.** Except where it is necessary to install the bronze tablet in an existing rock ledge, concrete pavement or a structure, the markers shall be either precast or cast in place at the option of the Contractor. Class SI Concrete shall be used throughout.

The location of the markers shall be according to the plans. The markers shall be placed at the P.T,'s and P.C.'s of horizontal curves and spaced along the tangents such that a minimum of 2 markers are always inter-visible.

The markers shall be placed under the direction of the Engineer and shall be installed in such a manner that there will be no future settlement or horizontal shifting.

The monuments shall be placed in a way that the survey point will fall within the portion of the tablet provided for that purpose.

The project designation, the centerline station, the survey point, and the elevation shall be permanently marked on the tablet by the use of metal dies after the marker has been installed.

**667.05 Basis of Payment.** The work of furnishing and erecting drainage markers will be paid for at the contract unit price each for FURNISHING AND ERECTING DRAINAGE MARKERS, which price shall include furnishing the markers and all excavation and backfill, except excavation in rock.

The work of furnishing and installing permanent survey markers will be paid for at the contract unit price each for PERMANENT SURVEY MARKERS, of the type specified, which price shall include furnishing the markers, either precast, cast in place, or drilled and set in existing ledge rock, concrete pavement or a structure, and permanently marking the tablet and all excavation and backfill except excavation in rock.

Excavation in rock will be paid for as specified in Section 502 for Rock Excavation for Structures.



### SECTION 668. PRESERVATION OF STONES AND OTHER MARKERS

**668.01 Description.** This work shall consist of preserving Section or Subsection Stones and other markers.

#### CONSTRUCTION REQUIREMENTS

- **668.02 General.** All stones and other markers encountered in the field shall be cross-tied prior to construction operations. This work shall be done by an Illinois Professional Land Surveyor. The Illinois Professional Land Surveyor shall reference the exact location of the existing monument, supervise the resetting of the monument, and prepare a monument record. The new monument record shall be filed in the County Recorder of Deeds at the County Court House in the County involved and a copy of the filed monument record shall be supplied to the District Chief of Surveys.
- **668.03 Basis of Payment.** This work will be paid for according to the requirements of Article 109.04.



# SECTION 669. REMOVAL AND DISPOSAL OF UNDERGROUND STORAGE TANKS

- **669.01 Description.** This work shall consist of the removal and proper disposal of underground storage tanks (UST), contents and associated underground piping to the point where the piping is above the ground, including determining the content types and estimated quantities.
- **669.02 Equipment.** All equipment shall comply with Occupational Safety and Health Administration (OSHA) and American Petroleum Institute (API) guidelines. Decontamination shall be performed on all equipment as appropriate to the hazardous substance and degree of contamination according to OSHA and API guidelines. All

cleaning fluids used to decontaminate the tanks and/or equipment shall be treated as the contaminant unless laboratory testing proves otherwise.

**669.03 Contractor Qualifications.** The Contractor shall be licensed and certified with the Office of the State Fire Marshall (OSFM) and shall possess all permits required to preform the work described in the plans and specifications.

**669.04 Contractor Requirements.** The Contractor shall contact the local OSFM in writing at least 30 days prior to starting the excavation to remove the tank(s). The Contractor shall also contact the Engineer and the local OSFM at least 72 hours prior to removal to confirm the OSFM inspector's presence during the UST removal. Removal, transport, and disposal of the UST shall be according to the applicable portions of the latest revision of the "American Petroleum Institute (API) Recommended Practice 1604".

The Contractor shall file a written health and safety plan applicable for all personnel working on the project. The health and safety plan shall pertain to any visitors or State employees at the site.

The Contractor shall provide a State certified manifest to the Engineer for the transport and disposal of all special and/or hazardous wastes and the removed tanks.

#### CONSTRUCTION REQUIREMENTS

**669.05 General.** Prior to removing an UST the Engineer will determine whether the Department is considered an "owner" or "operator" of the UST as defined by the UST regulations. Ownership of the UST refers to the Department's owning title to the UST during storage, use or dispensing of regulated substances. The Department can be considered an "operator" of the UST if it has control of, or voluntarily undertake actions to remove an UST from the ground without being deemed an "operator" of the UST.



In the event the UST is designated a leaking underground storage tank (LUST) by the OSFM's inspector and the Department is not an "owner" or "operator" of the UST, the Contractor shall notify the Engineer. Upon confirmation of a release from the UST the Contractor shall perform the following initial response actions:

- (a) Take immediate action to prevent any further release of the regulated substance to the environment.
- (b) Identify and mitigate fire, explosion and vapor hazards.
- (c) Remove as much of the regulated substance from the UST system as is necessary to prevent further release into the environment.
- (d) Visually inspect any above ground releases or exposed below ground releases and prevent further migration of the released substance into surrounding soils and groundwater.
- (e) Continue to monitor and mitigate any additional fire and safety hazards posed by vapors and free product that have migrated from the UST excavation zone and entered into subsurface structures (such as sewers or basements).

The disposal of any contaminated material shall be according to the appropriate State regulations. The Department is not required to notify IEMA of the release, only the "owner" or "operator" of the UST can report the release.

In the event the UST is designated a leaking underground storage tank (LUST) by the OSFM's inspector and the Department is an owner and/or operator of the UST the Contractor shall notify the Engineer. Upon confirmation of a release from the UST the Contractor shall perform the following initial response actions:

- (a) Report the release to the Illinois Emergency Management Agency (IEMA) (e.g. by telephone or electronic mail) and provide them with whatever information is available.
- (b) Take immediate action to prevent any further release of the regulated substance to the environment.
- (c) Identify and mitigate fire, explosion and vapor hazards.
- (d) Remove as much of the regulated substance from the UST system as is necessary to prevent further release into the environment.
- (e) Visually inspect any aboveground releases or exposed belowground releases and prevent further migration of the released substance into surrounding soils and groundwater.
- (f) Continue to monitor and mitigate any additional fire and safety hazards posed by vapors and free product that have migrated from UST excavation zone and entered into subsurface structures (such as sewers or basements).
- (g) Remedy hazards posed by contaminated soils that are excavated or exposed as a result of release confirmation, site investigation, abatement or corrective action activities.
- (h) Measure for the presence of a release where contamination is most likely to be present at the UST site, unless the presence and source of the release have been confirmed in accordance with regulations promulgated by the OSFM.
- (i) Investigate to determine the possible presence of the free product and begin free product removal as soon as practicable.

Removal and disposal of the contaminated materials shall be in accordance with the appropriate State regulations. The completion of the work under LUST conditions, may require a higher degree of personnel protection due to the leaking tank condition.

All contents within the tank shall be removed, transported and disposed of or recycled. The tanks shall be removed and rendered empty according to IEPA definition. This work shall include all required documentation, according to State, Federal and Local regulations and laws.

The proposal submitted for tank removal and related items shall be according to this Specification and the US EPA Publication SW-846, for sampling - analysis procedures.

All uncontaminated concrete and soil removed during tank extraction may be

used to backfill the excavation, at the discretion of the Engineer.

Soil and/or concrete removed from an excavation which is determined by the OSFM to be contaminated will not be allowed to be replaced in the excavation. This material shall be disposed of in either a special waste or hazardous waste landfill as mandated by definition of the contaminant.

The excavation resulting from the removal of the tanks, piping, and contaminated materials shall be backfilled according to the applicable paragraphs of Article 550.07. When trench backfill is required, it shall conform to the requirements of Section 208. Slurry, jetting, or inundation of aggregate fill material will not be permitted if the tank is designated a LUST. These operations will otherwise be permitted at the discretion of the Engineer.

Backfill material shall contain no frozen matter and shall not be placed on snow or ice. Jetting or inundating shall not be done during freezing weather.

After backfilling the excavation, the site shall be graded and cleaned to the satisfaction of the Engineer.

**669.06 Basis of Payment.** This work will be paid for at the contract unit price each for UNDERGROUND STORAGE TANK REMOVAL, which price shall include removing and disposing of the tank and its contents and piping, except for the removal and disposal of contaminated materials and the additional costs for a higher degree of personnel protection due to LUST conditions and the disposal of soil and/or concrete from an excavation determined to be contaminated, and shall include backfilling, water used for compaction, and final site grading and cleaning, except trench backfill.

The work of removing and disposing of contaminated materials from LUST and the disposal of soil and/or concrete from an excavation determined to be contaminated will be paid for according to Article 109.04.

The additional cost for a higher degree of personnel protection will be paid for according to Article 109.04.

Trench backfill will be paid for as specified in Article 208.04.

#### SECTION 670. ENGINEERS FIELD OFFICE AND LABORATORY

**670.01 Description.** This item shall consist of furnishing and maintaining in good condition for the exclusive use of the Engineer a weatherproof building or buildings hereinafter described at locations approved by the Engineer. Unless otherwise provided, the building shall be independent of any building used by the Contractor and all keys to the buildings shall be turned over to the Engineer. The Engineer will designate the location of the building and it shall remain on the work site until released by the Engineer.

Each field office or laboratory furnished shall be equipped with fire extinguishers having a minimum underwriters laboratory rating of 4A60BC.

**670.02** Engineer's Field Office Type A. Type A field offices shall have a ceiling height of not less than 2 m (7 ft.) and a floor space of not less than  $35 \text{ m}^2$  (380 sq. ft.). The office shall be provided with sufficient heat, natural and artificial

light, and air conditioning. Doors and windows shall be equipped with locks approved by the Engineer.

Windows shall be equipped with exterior screens to allow adequate ventilation. All windows shall be equipped with interior shades, curtains or blinds. Adequate all-weather parking space shall be available to accommodate a minimum of 10 vehicles.

Suitable on-site sanitary facilities meeting Federal, State and local health department requirements shall be provided and maintained clean and in good working condition and shall be stocked with lavatory and sanitary supplies at all times during the period of the contract.

Sanitary facilities shall include hot and cold potable running water, lavatory and toilet as an integral part of the office where available. Solid waste disposal consisting of 2 waste baskets and an outside trash container of sufficient size to accommodate a weekly provided pick-up service.

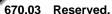
An electronic security system that will respond to any breach of exterior doors and windows with an on-site alarm will be provided.

In addition, the following equipment and furniture meeting the approval of the Engineer shall be furnished:

- (a) 4 desks with minimum working surface 1.1 m x 750 mm (42"x30") each and 5 non-folding chairs with upholstered seats and backs.
- (b) 1 desk with minimum working surface 1.1 m x 750 mm (42"x30") with height adjustment of 585 to 750 mm (23" to 30") for computer use.
- (c) 1 four-post drafting table with minimum top size of 950 mm x 1.2 m (37 1/2" x 48"). The top shall be basswood or equivalent and capable of being tilted through an angle of 50 degrees. An adjustable height drafting stool with upholstered seat and back shall also be provided.
- (d) 1 free standing 4 drawer legal size file cabinet with lock and an underwriters' laboratories insulated file device 350 degrees one hour rating.
- (e) 4 folding chairs.
- (f) 1 equipment cabinet of minimum inside dimension of 1100 mm (44") high x 600 mm (24") wide x 750 mm (30") deep with lock. The walls shall be of steel with a 2 mm (3/32") minimum thickness with concealed hinges and enclosed lock constructed in such a manner as to prevent entry by force. The cabinet assembly shall be permanently attached to a structural element of the field office in a manner to prevent theft of the entire cabinet.
- (g) 1 office style refrigerator with a minimum size of 0.2 m<sup>3</sup> (8 cu. ft.) with a freezer unit.
- (h) 1 electric desk type tape printing calculator and one pocket scientific notation calculator with a 1000 hour battery life or with a portable recharger.
- (i) 1 telephone, with touch tone, where available, and telephone answering machine, for exclusive use by the Engineer. A second separate telephone line, without telephone, shall also be provided for the exclusive use of the

Engineer.

- (j) 1 dry process copy machine capable of reproducing prints up to legal size [ 215 mm x 355 mm (8 1/2" x 14")] from nontransparent master sheets, as black or blue lines on white paper, including maintenance, reproduction paper, activating agent and power source.
- (k) 1 fax machine with paper.
- (I) 1 electric water cooler dispenser.



**670.04** Engineer's Field Office Type B. Type B field offices shall have a ceiling height of not less than 2 m (7 ft.) and a floor space of not less than  $11 \text{ m}^2$ 

(120 sq. ft.). The office shall be provided with sufficient heat, natural and artificial light, and air conditioning. Doors and windows shall be equipped with locks approved by the Engineer.

In addition, the following equipment and furniture meeting the approval of the Engineer shall be furnished:

- (a) 1 desk with minimum working surface 1.1 m x 750 mm (42" x 30") each and 1 non-folding chair with upholstered seat and back.
- (b) 1 file cabinet, letter size, 2 drawer.
- (c) 1 four-post drafting table with minimum top size of 950 mm x 1.2 m (37 1/2" x 48"). The top shall be basswood or equivalent and capable of being tilted through an angle of 50 degrees. An adjustable height drafting stool with upholstered seat and back shall also be provided.
- (d) 1 equipment cabinet of minimum inside dimension of 1100 mm (44") high x 600 mm (24") wide x 750 mm (30") deep with lock. The walls shall be of steel with a 2 mm (3/32 inch) minimum thickness with concealed hinges and enclosed lock constructed to prevent entry by force. The cabinet assembly shall be permanently attached to a structural element of the field office to prevent theft of the entire cabinet.
- (e) 1 telephone (for exclusive use by the Engineer).
- (f) 1 electric desk type calculator and 1 adding machine with tape or 1 tape printing calculator.

670.05 Engineer's Field Laboratory. The field laboratory shall have a ceiling height of not less than 2 m (7 ft.) and a floor space of not less than 18.5 m<sup>2</sup> (200 sq. ft.). The laboratory shall be provided with sufficient heat, natural and artificial light and air conditioning. Sanitary facilities as specified for Engineer's Field Office Type A shall also be included. Doors and windows shall be equipped with locks approved by the Engineer.

In addition, the following equipment and furniture meeting the approval of the Engineer shall be furnished:

- (a) 1 desk and chair
- (b) 1 drafting stool
- (c) 1 chair
- (d) 1 file cabinet, letter size, 2 drawer
- (e) 1 electric calculator
- (f) 1 telephone (for exclusive use by the Engineer)
- (g) 1 first-aid cabinet fully equipped
- (h) 1 service sink and water supply for testing purposes
- (i) 1 work bench 900 mm x 3 m x 900 mm (3' x 10' x 36") high with drawers and cabinets below and three 110 volt, 20 amp outlets above the bench.

**670.06 Mobile Units.** With the approval of the Engineer, a mobile unit or units of approximately the same dimensions and having similar facilities may be substituted for the above described building or buildings.

All mobile field offices and laboratories shall be tied down near the four corners at each end of the mobile unit. The tie-down equipment shall be of the type commonly sold by mobile home equipment suppliers to protect mobile homes in areas affected by hurricanes. The tie-down shall be made to the satisfaction of the Engineer.

The mobile unit shall be securely supported by adequate blocking. The blocking shall provide a foundation to prevent settlement.

A landing of minimum 1 m x 1 m (3' x 3') dimension shall be provided at each doorway with integral steps and railings.

670.07 Basis of Payment. The building or buildings fully equipped as specified, once accepted by the Engineer, will be paid for on a monthly basis until the building or buildings are released by the Engineer. The Contractor will be paid the contract bid price each month provided the building or buildings are maintained, equipped and utilities furnished. Payment will not be made when the contract is suspended according to Article 108.07 for failure of the Contractor to comply with the provisions of the contract. The building or buildings fully equipped, will be paid for at the contract unit price per calendar month or fraction thereof for ENGINEER'S FIELD OFFICE TYPE A, ENGINEER'S FIELD OFFICE TYPE B or ENGINEER'S FIELD LABORATORY. This price shall include all utility costs and shall reflect the salvage value of the building or buildings, equipment, and furniture which becomes the property of the Contractor after release by the Engineer, except that the Department will pay that portion of each monthly long distance telephone bill in excess of \$50.

Any extraordinary damage attributed to State operations during the course of the job will be repaired by the Contractor and may be paid for according to Article 109.04. No extra payment will be made for systems maintenance, repairs or replacement, or for damages incurred as a result of vandalism, theft or other criminal activities.

Art. 671.01 Mobilization

#### SECTION 671, MOBILIZATION

- **671.01 Description.** This work shall consist of preparatory work and operations necessary for the movement of personnel, equipment, supplies, and incidentals to the project site; for the establishment of offices, buildings and other facilities necessary for work on the projects; and for all other work or operations which must be performed or costs incurred when beginning work on the project.
- **671.02 Basis of Payment.** Upon execution of the contract, 3% of the total contract bid will be paid as the original mobilization payment.

The 3% will be recovered according to the following schedule.

- (a) When 10% or more of the original contract amount is earned, 1/5 of the original mobilization payment will be deducted from the current pay voucher.
- (b) When 20% or more of the original contract amount is earned, a cumulative 2/5 of the original mobilization payment will be deducted from the current pay voucher.
- (c) When 30% or more of the original contract amount is earned, a cumulative 3/5 of the original mobilization payment will be deducted from the current pay voucher.
- (d) When 40% or more of the original contract amount is earned, a cumulative 4/5 of the original mobilization payment will be deducted from the current pay voucher.
- (e) When 50% or more of the original contract amount is earned, the remaining balance of the original mobilization payment will be deducted from the current pay voucher.

# SECTION 700. WORK ZONE TRAFFIC CONTROL, SIGNING AND PAVEMENT MARKING

#### SECTION 701. WORK ZONE TRAFFIC CONTROL

**701.01 Description.** This work shall consist of the furnishing, installation, maintenance, relocation, and removal of all traffic control devices according to the contract.

**701.02 Materials.** Materials shall be according to the following Articles of Section 1000 - Materials:

	Item Artic	le/Section
(a)	Flashing and Steady Burning Barricade Lights	. 1084.01
(b)	Pavement Marking Tape	. 1095.06
(c)	Construction and Maintenance Signs	. 1084.04
(d)	Reflective Sheeting	. 1084.02
(e)	Temporary Rumble Strips	. 1084.03

## **CONSTRUCTION REQUIREMENTS**

## 701.03 Equipment.

	Item	Article/Section
(a)	Arrow Boards	1106.03
(b)	Sign Trailers	
(c)	Truck Mounted Attenuators	1106.01

#### 701.04 General.

(a) Applications. Traffic control and protection shall be according to the traffic control plan, Section 702 Traffic Control Devices, or as directed by the Engineer. The number, type, color, size, and placement of all traffic control devices shall be according to the traffic control plan, the Department's "Manual on Uniform Traffic Control Devices for Streets and Highways", and the Department's "Quality Standard for Work Zone Traffic Control Devices".

All existing pavement markings which conflict with the revised traffic pattern shall be removed according to Section 783.

Work shall not begin until the Engineer has determined the traffic control devices meet the quality requirements. Traffic control standards or designs included in the plans specify the minimum required combination of traffic control devices needed for a particular construction operation. Revisions or modifications of these standards or designs to fit field conditions shall be approved by the Engineer in writing.

Conditions created by the Contractor's operation, and not controlled by the contract shall be protected by safety devices at the Contractor's expense and as directed by the Engineer.

Temporary traffic control devices shall remain in place only as long as

needed and shall be removed as soon as practical when directed by the Engineer. Placement of any of these devices may be adjusted to fit field conditions. Signs that do not apply to current conditions, shall be removed, covered, or turned from the view of motorists.

At the preconstruction conference, the Contractor shall furnish the name of the individual in the Contractor's direct employ who is to be responsible for the installation and maintenance of the traffic control for the project. When the actual installation and maintenance are to be accomplished by a subcontractor, consent shall be requested of the Engineer at the time of the preconstruction conference. This shall not relieve the Contractor of furnishing a responsible individual in the Contractor's direct employ. The Department will provide the Contractor the name of its representative who will be responsible for the administration of the Traffic Control Plan.

For all projects which affect the flow of traffic for more than one day, form BT 725 will be required.

The maximum length of lane closure on multilane highways shall not exceed one day's production or 5 km (3 miles), whichever is greater, except lane closures up to 8 km (5 miles) in length will be permitted for portland cement concrete patching and continuously reinforced concrete patching operations. Gaps between successive lane closures shall not be less than 3 km (2 miles) in length.

- (b) Contractor's Operations and Equipment.
  - (1) General. The Contractor shall keep all equipment, materials, and vehicles off the pavement and shoulders on the side of the pavement which is open to traffic. The Contractor shall operate vehicles and equipment in the direction of traffic while traveling and working on the pavement and shoulders.

Excavation for construction on both sides of the pavement at any one location at the same time will not be permitted. At any location on existing pavements less than 3 lanes in width, the sequence of construction shall limit operations to one side of the pavement.

The maximum allowable differential in elevation between adjacent open traffic lanes shall be 50 mm (2 inches). At locations where construction operations result in a differential in elevation exceeding 75 mm (3 inches) between the edge of pavement or edge of shoulder within 900 mm (3 ft.) of the edge of the pavement and the earth or aggregate shoulders, Type I or II barricades or vertical panels shall be placed at 60 m (200 ft.) centers on roadways where the posted speed limit is 45 mph or greater and at 30 m (100 ft.) on roadways where the posted speed is less than 45 mph. This delineation will be considered as included in the contract unit prices for the work and no additional compensation will be allowed.

(2) Surveillance. When open holes, broken pavement, trenches over 75 mm (3 inches) deep and 100 mm (4 inches) wide or other hazards are present adjacent to an open lane, in a closed lane, or adjacent to the closed lane, the Contractor shall furnish Traffic Control Surveillance

during all hours when the Contractor is not engaged in construction operations. The surveillance person(s) shall be provided with adequate transportation and communications to ensure deficiencies can be corrected. The surveillance person(s) shall drive over and inspect the work, maintain the temporary traffic control devices, and assist and direct traffic, at such intervals as may be required, not to exceed 4 hours. The person responsible for surveillance shall complete an inspection form, furnished by the Engineer, on a daily basis. The completed form shall be given to the Engineer on the first working day after the inspection.

(3) Equipment Parking and Storage. During working hours, all vehicles and/or nonoperating equipment which are parked, 2 hours or less, shall be parked at least 2.5 m (8 ft.) from the open traffic lane. For other periods of time during working and for all nonworking hours, all vehicles, materials, and equipment shall be parked or stored a minimum of 9 m (30 ft.) from the pavement when the project has adequate right of way. When adequate right of way does not exist, vehicles and materials shall be located at least 4.5 m (15 ft.) from the edge of any pavement open to traffic, unless located behind temporary concrete barrier, temporary bridge rail, or other man-made or natural barriers. Temporary barriers erected for protection by the Contractor shall meet the approval of the Engineer. When authorized by the Engineer, vehicles, materials, or equipment may be parked or stored, less than 4.5 m (15 ft.) from any pavement open to traffic.

Any unattended obstacle or excavation in the work area which constitutes a hazard in the opinion of the Engineer, shall be protected by barricades at 15 m (50 ft.) centers, having flashing lights at night. If the hazard exceeds 30 m (100 ft.) in length, steady burning lights shall be substituted for flashing lights. When the distance is greater than 75 m (250 ft.), barricade spacing may be increased to 30 m (100 ft.).

When not being utilized to inform and direct traffic, construction speed limit signs, arrow boards, and message boards shall be treated as nonoperating equipment.

(4) Crossovers. The Contractor will be permitted to make "U" turns across the median at existing maintenance crossovers or crossovers constructed by the Contractor, provided the width of the crossover is adequate to ensure no disruption of traffic on the through lanes and at locations permitted by the Engineer. The use of median crossovers will not be permitted within 400 m (1320 ft.) of the speed change taper of an interchange ramp, within 600 m (2000 ft.) of the taper for a lane closure, or when the construction traffic will be entering or exiting the only open lane within a construction zone. Crossovers shall conform to minimum sight distance requirements. The cost of constructing, maintaining, and removing temporary crossovers and the restoration of the median shall be at the Contractor's expense. When the crossover is being used, 2 signs shall be placed in the median and 2 signs shall be placed opposite on the outside shoulder of the highway in advance of the crossover on the side where trucks enter the

highway. The first pair, approximately 300 m (1000 ft.) from the crossover, shall be 1.2 m (48 inch) MERGE RIGHT signs. The second pair, approximately 450 m (1500 ft.) from the crossover, shall be 1.2 m (48 inch) TRUCKS ENTERING ON LEFT signs. The warning signs in advance of the crossover in the other direction shall be as listed above except the second pair shall be TRUCKS LEAVING ON LEFT. All warning signs required at median crossovers shall be at the Contractor's expense.

## (c) Flaggers.



- 1) General. The flagger shall be stationed to the satisfaction of the Engineer and equipped with fluorescent orange or fluorescent orange and strong yellow/green vests and approved flagger traffic control signs conforming to Standard 702001 and Article 702.05(e). The longitudinal placement of the flagger may be increased up to 30 m (100 ft.) from that shown on the plans to improve the visibility of the flagger. Flaggers will not be required when no work is being performed, unless there is a lane closure on 2-lane, 2-way pavement.
- (2) Two Lane Highways. Two flaggers will be required for each separate operation where 2-way traffic is maintained over one lane of pavement. Work operations controlled by flaggers shall be no more than 1600 m (1 mile) in length. Flaggers shall be in sight of each other or in direct communication at all times. Direct communication shall be obtained by using portable two-way radios or walkie-talkies.
- (3) Multilane Highways. At all times where traffic is restricted to less than the normal number of lanes on a multilane pavement with a posted speed limit greater than 40 mph and the workers are present, but not separated from the traffic by physical barriers, a flagger shall be furnished to protect the workers and to warn and direct traffic. One flagger will be required for each separate activity of an operation that requires frequent encroachment in a lane open to traffic.
- (4) Flagger Certification. All flaggers engaged in work zone traffic control operations are required to be certified by the Illinois Department of Transportation or by an agency approved by the Department. While on the job site, each flagger shall have in his/her possession a current drivers license and a current flagger certification I.D. meeting Department requirements. For non-drivers, the Illinois Identification Card issued by the Secretary of State will meet the requirement for a current drivers license.

This flagger certification shall not apply to any emergency situations that arise due to actions beyond the Contractor's control where flagging is needed to maintain safe traffic control on a temporary basis.

- (5) Flagger Signals. The flagger signaling methods shall comply with those contained in the Department's Flagger Handbook.
- (6) Night Time Flagging. The flagger station shall be lit by additional overhead lighting other than street lights. The flagger's vest shall be retroreflective. The retroreflective material shall be orange, yellow, white, silver or strong yellow/green. It shall be visible at a minimum

distance of 300 m (1000 ft.) and shall be designed to identify the wearer as a person through the full range of body motions.



Traffic Control Modification. Revisions in the phasing of construction or maintenance operations may require traffic control to be installed according to Standards other than those included in the contract plans. If required, the Standards will be made available to the Contractor at least one week in advance of the modification of the traffic control. A modification to increase the traffic control shown in the plans by the Contractor must be submitted to the Engineer for approval. A reduction in the traffic control will not be allowed except as provided herein.

A reduction in the number of flaggers from that shown on the contract may be permitted when the road is closed to through traffic and it is necessary to provide access for local traffic. If the average daily traffic is 400 or more, or is not shown in the contract, the Contractor shall furnish flaggers and traffic control devices according to the contract. When the road is closed to through traffic, but open to local traffic and the average daily traffic, as shown in the plans is less than 400, but more than 100, one flagger will be required for each separate operation where two-way traffic is maintained over one lane and no flaggers will be required where at least one unobstructed lane of traffic is maintained, in each direction on multilane pavements. When the average daily traffic is less than 100, no flaggers will be required unless the Contractor's operation encroaches on the open traffic lane, during which time one flagger shall be provided at the Contractor's expense. If the average daily traffic volume is less than 400, the Engineer may required additional flaggers to protect hazardous conditions and such additional flaggers will be paid for according to Article 109.04.

- (e) Temporary Rumble Strips. Temporary rumble strips shall be placed snugly against one another and attached to the pavement with an adhesive meeting the recommendations of the rumble strip manufacturer.
- (f) Truck Mounted Attenuators. Trailing vehicles shall be between 60 m and 150 m (200 ft. and 500 ft.) behind the lead vehicles.

## 701.05 Specific Procedures.

- (a) Shoulders.
  - (1) Aggregate.

When bituminous resurfacing is being constructed and the road is open to traffic, there shall be no more than 6.5 lane-km (4 lane-miles) of completed surface adjacent to the shoulder without either completing the shoulders, providing barricades or vertical panels as required by Article 701.04(b), or constructing a temporary earth wedge against the edge of the pavement and compacting it to the satisfaction of the Engineer.

(2) Portland Cement Concrete. When the curing period for the concrete shoulders, as required in Article 1020.13, has been completed, the Engineer will determine when traffic will be permitted on the shoulders. No traffic will be permitted on the shoulders until test specimens conforming to the requirements of Article 1020.09 have attained a minimum flexural strength of 3.5 MPa (500 psi), or a minimum compressive strength of 19 MPa (2,700 psi). If such tests are not conducted, traffic will not be permitted on the shoulders until 14 days after the concrete is placed.

The Contractor may request additional test specimens be made and tested if he/she wishes to permit traffic on the shoulders earlier than the normal testing frequency. These specimens will be cured in the same manner as the shoulders.

## (b) Base Course.

- Aggregate Base Course. The road or any section 1.5 km (1 mile) or more in length shall be opened to traffic immediately after it has been completed.
- (2) Soil-Cement Base Course. The finished soil-cement base course may be opened immediately to local traffic and to the Contractor's construction equipment. The base may be opened to all traffic after the 7-day protection period, provided the base course is not damaged, marred, or distorted by such traffic, and provided the protection and cover specified in Article 352.12 is not impaired.
- (c) Surface Courses and Pavement. Where construction operations on two-lane roads open to traffic result in the removal or covering of any pavement striping indicating passing restrictions, "No Passing Zones Not Striped Next Miles" signs shall be used. The Contractor shall place the signs at the beginning of the unstriped area, just beyond each major intersection within the unstriped area, and at other locations as directed by the Engineer to ensure a minimum spacing of 8 km (5 miles). The signs shall be placed just prior to removal or covering of the striping and shall remain in place until full no passing zone striping has been restored.
  - (1) Prime Coat. The "Fresh Oil" (W21-2) sign shall be erected when prime and fine aggregate are applied to pavement that is open to traffic. The signs shall remain until tracking of the prime ceases as directed by the Engineer. The signs shall be erected a minimum of 150 m (500 ft.) preceding the start of the prime.
  - (2) Cold Milling. The "Rough Grooved Surface" (W8-I107) signs shall be erected when the road has been cold milled and opened to traffic. The signs shall remain in place until the milled surface condition no longer exists. These signs shall be erected a minimum of 150 m (500 ft.) preceding the start of the milled pavement and shall have an amber flashing light attached.
  - (3) Bituminous Concrete Binder and Surface Course Class I. The road shall be kept open to traffic on the existing pavement or on the new work. During the actual cleaning of the pavement and the placing of the mixture for cracks, joints and flangeways, prime coat, leveling binder, binder and surface courses, one-way traffic will be permitted. At all other times, two-way traffic will be allowed to use the road.

(4) Bituminous Treated Earth Surface. When blotter aggregate is not specified, the road shall be closed to traffic during the application of the bituminous material and shall remain closed for a period of not less than 48 hours after the final application, or longer if deemed necessary by the Engineer. Excess bituminous material remaining on the surface at the time the road is closed to traffic, shall be covered with a thin layer of loose earth sufficient to absorb the surplus bituminous material.

When blotter aggregate is specified, the road may be opened to traffic immediately after the application of blotter aggregate.

- (5) Bituminous Surface Treatment and Surface Plant Mix (Class B). The surface may be opened to traffic as soon as it has cured sufficiently to prevent the material from being picked up by the wheels of vehicles passing over it.
- (6) Portland Cement Concrete Pavement. When the curing period for the pavement, according to Article 1020.13, has been completed and the joints have been sealed, as required in Article 420.10, and protective coat, when required, is applied, the Engineer will determine when the pavement shall be opened to traffic. The earliest the pavement will be opened to traffic will be when test specimens according to Article 1020.09 have attained a flexural strength of 4.5 MPa (650 psi) or a compressive strength of 24 MPa (3500 psi). If such tests are not conducted, the pavement shall not be opened to traffic until 14 days after the concrete is placed. Prior to opening to traffic, the pavement shall be cleaned.

The Contractor may request additional test specimens be made and tested if the Contractor wishes to open the pavement to traffic earlier than the normal testing frequency. These specimens will be cured in the same manner as the pavement. All traffic including construction traffic shall be limited to legal axle weights (legal loads).

#### (d) Structures.

(1) Concrete Superstructures and Floors. Concrete superstructures and floors shall be opened to traffic according to Articles 503.05, 503.06, and 1020.13 and after protective coat, when required, is applied and final texturing or grooving is completed unless stage construction is utilized.

On projects utilizing stage construction, saw cut grooving may be deferred until at least two adjacent lanes have been constructed.

- (2) Box and Pipe Culvert Extensions. Box culvert and pipe culvert extensions shall be protected with barricades until the backfill over the extensions is complete and no longer poses a hazard to traffic.
- (3) Storm Sewers Jacked in Place. The construction operations shall be carried on without encroachment upon the traveled way by either the excavation or by the storage of equipment or materials. When open cut excavation encroaches upon the shoulder, the excavation shall be

protected according to Article 701.04(b).

- (4) Bridge Washing. The entire bridge roadway and roadways below shall be kept open to traffic at all times, other than when actual work is being performed. While actual work is being performed, one-half the roadway may be closed to traffic at the option of the Contractor. One-way traffic shall be permitted over the other half of the roadway if the bridge roadway is less than 12.2 m (40 ft.) in width. Two-way traffic shall be permitted over the other half of the roadway if the bridge roadway width is 12.2 m (40 ft.) or more between curbs. Traffic control devices shall be as specified for each bridge.
- (e) Pavement Patching.
  - (1) Keeping Road Open to Traffic. Traffic shall be permitted to use the road at all times. All construction operations shall be arranged to facilitate the movement of traffic.
    - a. Open Traffic Lane. On two-lane pavements, construction operations shall be confined to one traffic lane, leaving the opposite lane open to traffic. On 4-lane pavement, construction operations shall be confined to 1 traffic lane in each direction, leaving the other 2 traffic lanes open to traffic throughout the period of construction.
    - b. Temporary Traffic Control Devices. In addition to the traffic control and protection shown elsewhere in the contract for multi-lane pavement, the Contractor shall place two barricades or drums immediately in front of each open patch or other excavation within a closed lane adjacent to an open lane where temporary concrete barriers are not used to separate traffic from the work area. One barricade or drum shall be placed at the edge of the open traffic lane and one barricade or drum centered in the closed lane. A check barricade shall be placed in the middle of the closed lane and at the shoulders at 300 m (1000 ft.) centers.

When patching on ramps, a minimum of 3 standard 1.2-m (48 inch) signs (RAMP CONSTRUCTION, NARROW LANE, and FLAGGER or Flagger Symbol signs) and 1 flagger shall be required as directed by the Engineer. The work area shall be delineated by Type I or Type II barricades at 15 m (50 ft.) spacing or closer if directed by the Engineer. Cones may be substituted for barricades during daylight hours. This work shall be included in the cost of Standard 701406 or 701401.

Barricades or drums being used to separate traffic from the work area may be moved up to 15 m (50 ft.) from their specified location. Flaggers, when required, shall be provided according to Article 701.04(c).

c. Scoring. As soon as the scoring operations are completed and before the barricades are removed, all spalls and broken pieces of concrete shall be removed from the pavement and shoulders. Waste material shall be disposed of by the Contractor at the Contractor's own expense according to Article 202.03.

- d. Broken Pavement and Open Holes.
  - Multilane Roadways. The total area of pavement broken and not removed for concrete patching shall not exceed 1/2 of the total area of broken pavement which can be removed in an average day's work. The total area of holes left open overnight for concrete patching shall not exceed 1/2 of the pavement area which can be replaced in an average day's work. All open holes, broken pavement and patches shall be barricaded as shown on the plans. No materials removed from patches shall remain on the right of way overnight.

No open holes, broken pavement, or partially filled holes shall remain overnight on bituminous patching or when use of the special patching mixture is required, except for conditions beyond the Contractor's control.

 Two Lane Roadways and Ramps. No open holes, broken pavement, or partially filled holes shall remain overnight and all barricades shall be removed before dark, except for conditions beyond the Contractor's control.

- (2) Opening Road to Traffic.
  - a. Cleaning Up. Prior to opening the pavement to traffic, the entire right of way adjacent to the patching operations shall be cleared of all materials caused by the Contractor's operations, and the backfill along the shoulder edge of the pavement shall be compacted to the satisfaction of the Engineer.
  - b. Strength Tests. The patch may be open to traffic when test specimens cured with the patch have obtained a minimum flexural strength of 4.1 MPa (600 psi) or a compressive strength of 22 MPa (3200 psi). With the approval of the Engineer, concrete strength may be determined through the use of a maturity meter according to AASHTO T 276. At the age of 2 days, testing will be permitted for high-early-strength concrete, rich-mix portland cement concrete, or a concrete mixture containing an approved accelerator.
  - c. Special Mixture. The special patching mixture according to Article 1020.05(g)(2) shall be utilized when specified. These patches shall be cured and opened to traffic during daylight hours on the same day the patches are constructed.

Patches constructed of the special patching mixture on ramp pavements and 2-lane pavements with 2-way traffic may be open to traffic when beams cured with the patches achieve a flexural strength of 2100 kPa (300 psi), or a compressive strength of 11,000 kPa (1600 psi) determined as specified in Article 1020.09. For all other pavements, patches constructed with the special patching mixture may be opened to traffic when beams cured with the patches achieve a flexural strength of 3800 kPa (550 psi) or

a compressive strength of 20,200 kPa (2,933 psi).



The following Tables 1 and 2 list estimated hours from placement to opening to traffic for various initial ambient temperatures, mixtures, and curing condition. These tables are provided for informational purposes only. The regular patch referred to in the tables is a 7-bag mix with calcium chloride and air entrainment only.

TABLE 1
ESTIMATED MINIMUM TIME FROM PLACEMENT TO OPENING TO TRAFFIC
(Based on 2100 kPa (300 psi) Opening Flexural Strength)

## Minimum Number of Hours to Opening

	Ambient Temperature @ Placement °C ( °F.)		Regular Patch	Regular Patch With Super Plasticizer	Regular Patch With Insulation	Regular Patch With Super Plasticizer And Insulation
	13-14 15-16 17-18 19-20 21-22 23-24 25-26 27-28 29-30 31-32	55-58 59-61 62-65 66-68 69-72 73-75 76-79 80-83 84-86 87-90	32 29 25 22 19 15 12 10 8 7	25 22 20 17 15 12 10 8 6 5	14 11 9 8 7 6 5 5 5 5	11 8 7 6 5 5 5 5 5
 	33-34 Above 34	91-93 Above 93	6 5	5 5	5* 5*	5* 5*

<sup>\*</sup>Do not place insulation when ambient temperature is greater than 32 °C (90 °F.)

TABLE 2
ESTIMATED MINIMUM TIME FROM PLACEMENT TO OPENING TO TRAFFIC (Based on 3800 kPa (550 psi) Opening Flexural Strength)

### Minimum Number of Hours to Opening

Ambient Temperature @ Placement °C ( °F.)		Regular Patch	Regular Patch With Super Plasticizer	Regular Patch With Insulation	Regular Patch With Super Plasticizer And Insulation
13-14	55-58	36	29	17	15
15-16	59-61	32	25	14	11
17-18	62-65	29	22	12	10
19-20	66-68	25	20	11	9
21-22	69-72	22	17	10	8
23-24	73-75	19	15	9	8
25-26	76-79	15	13	8	8
27-28	80-83	13	11	8	7
29-30	84-86	11	9	8	6
31-32	87-90	10	8	7	6
33-34	91-93	9	8	6*	6*
Above 34	Above 93	9	8	6*	6*

<sup>\*</sup>Do not place insulation when ambient temperature is greater than 32 °C (90 °F.)

When use of the special patching mixture is required and patches cannot be opened before sunset, the additional traffic control required will be provided by the Contractor at his/her own expense. The Contractor will be required to change his/her operations if she/he consistently cannot have all patches open before nightfall.

(f) Guardrail. Traffic control for the installation, maintenance, and/or removal of guardrail shall be provided, as applicable to 2-lane or multi-lane roadways, according to the following Highway Standards included in the plans:

# Two-lane Roadways Multi-lane Roadways

Standard 701006 Standard 701011 Standard 701201 Standard 701301 Standard 701311



In addition to applicable Standard requirements, Type I or II barricades with lights shall be placed at 15 m (50 ft.) centers at all locations where guardrail is temporarily removed or where the installation is incomplete. The barricades shall remain in place until the guardrail installation is completed.

Guardrail removal and/or installation shall be coordinated to prevent delays in completion. Guardrail removal and/or installation shall be scheduled so

no installations are left unfinished when the work is suspended for the winter or other extended periods of time.

These Standards will not be paid for separately and all costs shall be included in the applicable guardrail installation, maintenance, and/or removal pay items.

**701.06 Highway Standards Application.** Standards for work zone traffic control shall be applied to locations according to existing posted speed limits.

- (a) Standard 701006 and 701011. When the work operation requires 4 or more work vehicles enter through traffic lanes in a one hour period, a flagger shall be provided and a FLAGGER sign shall be substituted for the WORKER sign.
- (b) Standard 701316 and 701321. The exact location of the signals, detector loops, stop bars, and signs shall be as directed by the Engineer.

Advisory speed signs or plates, showing a speed of 10 mph less than the normal posted speed shall be installed.

The Contractor shall notify the Engineer for inspection, at least 72 hours in advance of placing the signals in operation.

The District Engineer shall be notified one week prior to a traffic lane width reduction.

Any damage to the temporary traffic signals from any cause shall be repaired at the Contractor's expense. If at any time the Contractor fails to perform any work deemed necessary by the Engineer to keep the temporary traffic signals in proper operating condition, the Department reserves the right to have other electrical Contractors perform the needed work, and the cost will be deducted from compensation due or which may become due the Contractor under the contract.

- (1) Standard 701316. During daytime operations when workers are present, the Engineer may allow Type I or Type II barricades to be placed parallel to the centerline. Cones may be substituted for barricades at half the barricade spacing during the daytime operations.
- (2) Lane Closure on 2-Way, 2-Lane Rural Road. The Contractor shall furnish, install, maintain, and remove temporary traffic signals including a traffic actuated controller, a cabinet, detector amplifiers, and other associated equipment as listed below and on Standards 701316 and 701321 for each location specified. The Contractor shall have available one spare controller and cabinet. The Contractor shall retain ownership of all traffic control equipment, miscellaneous accessories, and the installation methods shall be according to the following:



a. Traffic Signal Heads. Two signal heads shall be provided for each approach and all signal faces shall have new lamps when installed. When the signals are not operating, the signal head shall be hooded according to Article 840.03 and the "SIGNAL AHEAD" sign covered or removed. The left signal head shall be mounted at a height of 3.1 m (10 ft.) above the road surface measured to the bottom of the signal head. The right signal head shall be mounted at a height of 4.3 m (14 ft.) above the road surface. Back plates will be required on all signals.

The right signal head shall be aimed so the centers of the light beams of the indications are directed toward a point in the center of the approach lane 150 m (500 ft.) in advance of the signal. The left indication shall be aimed at a point in the center of the approach lane 30 m (100 ft.) in advance of the stop line.

- b. Lenses. All lenses shall be 300 mm (12 inch) nominal diameter.
- c. Wire and Cable. The Contractor shall supply all overhead and underground wiring for both signal circuits and loop detector lead-ins. The electric cable shall be aerially suspended, at a minimum height of 2.5 m (8 ft.) and as close to the right of way line as possible. When the electric cable crosses a roadway, or entrance it shall be aerially suspended, at a minimum height of 5.5 m (18 ft.), according to the local utility requirements, or placed in a trench with a minimum of 50 mm (2 inches) of cover or protected in a manner approved by the Engineer.
- d. Mounting. The controller shall be mounted on a post, pole, or temporary concrete foundation. The signal heads shall be mounted on 7.5 m (25 ft.) standard tubular steel posts or on a minimum Class 4 wood pole, when overhead wiring is used between signals. Alternative methods of mounting the cabinet or signal heads shall be approved by the Engineer. The supports shall be kept in a vertical position for the duration of the project.
- e. Service Installation. The Contractor shall be responsible for the installation and cost of 110-volt electrical service. When the service cable from the controller to the power source is suspended overhead, the line height shall not be less than 2.5 m (8 ft.) above the ground and located as close to the right of way lines as practicable. When the cable crosses a roadway or entrance, the cable shall be raised to a minimum height of 5.5 m (18 ft.) or pass under the pavement through a culvert opening. Portable power generating equipment may be used for a short period of time until local power is available, provided at least one person is present at all times at the site to ensure proper operation.
- f. Traffic Signal Controller.
  - 1. The controller shall be a standard 8 phase NEMA controller housed in a weather proof cabinet. The traffic signals shall dwell in All-Red. When an additional phase is used for a side road movement, only one long red interval shall be used between active phases on each side of the work area. The long all red intervals shall be adjustable up to 99 seconds in one second increments. Long all red intervals shall be

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obtained by using a trail green feature or an equivalent or by using dummy phases. The long all red interval shall be pre-empted if the previous movement is detected before the conflicting movement is detected and shall cause the previous movement to return to the green display with a minimum 4 second delay. When a conflict or failure is detected, the signal shall display a flashing All-Red.

All devices used, in lieu of controller software to produce this sequence, shall be mounted within the cabinet but not within the controller. The Contractor shall provide an operational demonstration of the controller assembly for the Engineer subsequent to installation and prior to being placed into operation. The Contractor shall program the controller, trouble shoot, and correct any problems that arise, and verify the equipment is functioning according to the contract. If any controller malfunction occurs during the time of operation or in the event of a power failure, the Contractor shall, without delay, provide flaggers for traffic control and immediately install a replacement controller to operate the signals.

- When specified, the Department will furnish the traffic 2. actuated controller. The controller, complete with loop detector-amplifiers and pole mount cabinet, shall be picked up and returned upon completion of the project to the location designated on the plans. The Contractor shall provide notice to the Department at least 2 weeks in advance of requiring the traffic actuated controller. The Contractor shall be responsible for maintenance of the controller and all related equipment within the controller cabinet. The controller shall be inspected by the Contractor and Engineer subsequent to installation and prior to being placed into operation. Any malfunction of the Department owned equipment revealed during the inspection by the Contractor shall be repaired and will be paid for according to Article 109.04. The Contractor shall be responsible for any damage to the Department-owned equipment as a result of negligence or poor workmanship during installation at his/her expense. The Contractor shall provide all maintenance required, at his/her expense, to keep the Department-owned equipment functioning properly after being placed in operation.
- g. Detector Loops. Three detector loops shall be installed on each approach as shown on the plans. The near detector loops shall be placed 300 mm (12 inches) from the centerline and the far loop shall be placed 300 mm (12 inches) from the edge line. Each loop shall be connected to a separate detector amplifier channel. Call delay feature shall be used for the loops nearest the stop lines and defeated during the green of that phase. An alternate method of detection may be used if it has been demonstrated and approved by the Department.

The loop detector lead-in cable shall be protected from construction and maintenance activities. In the event of detector loop failure, the Contractor shall have 48 hours to repair or replace the loops. Upon completion of the project, the detector loop shall be terminated in such a manner as to provide for future use.

- (c) Standard 701326. No paving or excavating operations shall be performed at night unless authorized by the Engineer.
- (d) Standard 701336. Two flaggers shall be required for each separate construction operation. The flagger shall be a minimum of 60 m (200 ft.) and a maximum distance of 1/2 day's operation beyond the flagger sign and a minimum of 30 m (100 ft.) in advance of the work party.

Under restricted sight distance conditions, additional devices may also be required for distances less than 600 m (2000 ft.) at the discretion of the Engineer.

During periods when workers are present all work areas shall be protected by cones or barricades along the centerline.

- (e) Standard 701101. When the work operation requires 4 or more work vehicles enter through traffic lanes in a one hour period, a flagger shall be provided and a FLAGGER sign shall be substituted for the WORKER sign. When the work operation is 4.5 m (15 ft.) or more off the pavement edge, no signing or cones will be required, unless 2 or more vehicles cross the 4.5 m (15 ft.) clear zone in one hour.
- (f) Standard 701406 and 701401.
  - General. When Standard 701401 is specified for overnight operations, cones may be substituted for barricades or drums at half the spacing during day operations.
  - (2) Multilane Pavement Resurfacing. For the construction of binder course, surface course and shoulder resurfacing on multilane pavements, Standard 701406 or 701401 shall be used from the beginning of business on Monday to 4:30 p.m. on Friday. Only Standard 701406 may be used from 4:30 p.m. Friday to start of business on Monday.
  - (3) Shoulder Upgrading and Replacement. The following shall apply to shoulder pipe underdrain installation and/or shoulder reconstruction on existing multilane divided highways.

The Contractor shall close the adjacent lane of pavement within the limits of the construction zone, when required by the Contractor's operations. When no workers are present and the difference in elevation between the pavement and the shoulder and/or widening is greater than 75 mm (3 inches), the Contractor shall place barricades according to Article 701.04(b).

During shoulder work on ramps, a minimum of two standard advance signs, a 1.2-m (48 inch) RAMP CONSTRUCTION AHEAD, and a

## Work Zone Traffic Control

1.2-m (48-inch) FLAGGER AHEAD or Flagger Symbol sign, and one flagger shall be used as directed by the Engineer. The work area shall be delineated by Type I or II barricades or vertical panels at 15 m (50 ft.) spacings or closer if directed by the Engineer. Shoulder drop-offs greater than 40 mm (1 1/2 inches) caused by the Contractor's operations will be allowed only on one side of the ramp at a time. This work shall be included in the cost of Standard 701406 or 701401.

Standard 701401 will only be measured for payment where the average depth of shoulder reconstruction required by the plans, exclusive of any trench for pipe underdrain installation, is in excess of 75 mm (3 inches). Where such shoulder reconstruction is 75 mm (3 inches) or less, no open trench greater than 75 mm (3 inches) deep shall be permitted overnight. If, because of unforeseen circumstances, an open trench greater than 75 mm (3 inches) deep should occur overnight, the Contractor shall, at his/her own expense, close the adjacent traffic lane according to Standard 701401.

Excavations greater than 75 mm (3 inches) in depth between the pavement and shoulder, including any trenches within the shoulder area, shall be restricted to one shoulder in each direction of travel. In addition, shoulder drop-offs greater than 40 mm (1 1/2 inches) caused by the Contractor's operations will not be permitted over the winter shutdown.

The Contractor shall schedule the work so the lane closure at any one work area does not exceed 5 working days. The closure time may be exceeded for conditions beyond the Contractor's control, except if continual and persistent closures in excess of the 5 working days are made, the Engineer will initiate measures to delay or limit the daily production of the Contractor's operations.

All debris shall be removed from the shoulder and right of way prior to the removal of barricades, drums or vertical panels.

(g) Standard 701421 and 701416. Reflective solid edge lines and double vellow centerline shall be used when the closure time exceeds 4 days or when the normal posted speed outside the area of operations exceeds 80 km/h (50 mph). Reflectorized pavement marking tape shall be used for marking the edge lines and centerline on existing pavement. Either tape or reflectorized pavement marking paint may be used for markings on the paved crossovers. Raised reflective pavement markers at 8 m (25 ft.) centers shall also be installed under good weather conditions, for additional



delineation.

When Standard 701421 is specified, drums, or Type I or Type II barricades no greater than 600 mm (24 inches) wide, may be used in place of flexible delineators when the 2-way operation is to be in place for 4 days or less. Cones may be used at half the spacing for day operations only.



When Standard 701416 is specified, the impact attenuator shall be positioned so as not to encroach onto the outer lane. Vertical panels may be attached to the concrete barriers where available space prohibits the use of drums.

(h) Standard 701431. Reflective solid edge lines and a double yellow centerline shall be used when the closure time exceeds 4 days or when the normal posted speed outside the area of operations exceeds 50 mph. Reflectorized pavement marking tape shall be used for marking the centerline and edge lines on the existing pavement. Raised reflective pavement markers at 8 m (25 ft.) centers shall be installed under good weather conditions to supplement the pavement marking tape. All existing pavement markings which conflict with the revised traffic pattern shall be removed.

Drums, or Type I or Type II barricades no greater than 600 mm (24 inches) wide, may be used in place of flexible delineators when the two-way operation is to be in place 4 days or less.



- (i) Standard 701426. Truck mounted attenuators will not be required for any vehicle traveling entirely on a completed shoulder or for vehicles traveling on the roadway if the speed limit of the roadway is less than 45 mph.
- (j) Standard 701411. This Standard shall supplement mainline traffic controls for lane closures.

The channelizing devices shall clearly define a path for motorists entering or exiting the highway.

Reflectorized temporary pavement marking tape shall be placed throughout the barricaded area of each ramp where the closure time is greater than 14 days. Raised reflectorized pavement markers at 8 m (25 ft.) centers may be used in lieu of tape where the pavement marking is to be placed adjacent to the barricades or drums.

- (k) Urban Traffic Control, Standards 701501,701606, 701601, 701701, 701801.
  - General. "NO PARKING" signs shall be installed throughout the work area.

When the work area is in the parking lane and parking exists during work hours, "ROAD CONSTRUCTION AHEAD" or "ROAD WORK AHEAD" signs shall be installed 60 m (200 ft.) in advance of the work area and the area shall be protected with cones or barricades.

Reflectorized temporary pavement marking tape shall be placed throughout the taper and along side the adjacent work area where the closure is greater than 14 days. The edge line shall be yellow for left lane closures.

- (2) Standard 701501. When Standard 701501 is specified on two-lane/two-way roadways, construction operations shall be confined to one traffic lane leaving the opposite lane open to traffic.
- (3) Standard 701606. When Standard 701606 is specified reflective pavement markings shall be used when the closure time exceeds 4 days. The double yellow center line shall be used in the two-way traffic area in addition to the barricades or drums. Single yellow left edge line

shall be used to outline the barricade island. White right edge line shall be used along the barricades protecting the work area.

(4) Standard 701801. On Standard 701801, where a temporary walkway encroaches on an existing parking lane, the lane shall be closed with cones, barricades, or drums.

Where a temporary walkway encroaches on a traveled lane, the lane shall be closed according to Standards 701501, 701606, or 701601.

All walkways shall be clearly identified, protected from motor vehicle traffic and free of any obstructions and hazards, such as holes, debris, construction equipment, and stored materials.

All hazards near or adjacent to walkways shall be clearly delineated.

When barricades are impractical to use or do not provide enough protection, orange safety fence shall be used to close off an area, with the approval of the Engineer.

#### 701.07 Method of Measurement.

(a) Not Measured. Traffic control and protection required under Standards 701001, 701006, 701011, 701301, 701311, 701426, 701106, and 701101 will not be measured for payment.

The work specified for Work Zone Speed Limit signing in Article 702.05(d) will not be measured for payment.



Measured as Each. Traffic control and protection required under Standards 701316, 701331, 701421, 701431, 701321, 701416, and 701411 will be measured for payment at each location specified. For Standard 701411, each ramp will be measured as a separate location and will be considered as a separate location for payment. Standard 701401 will be measured for payment on an each basis only when the traffic control and protection applies to isolated stationary work areas and does not involve or is a part of other protected areas.

Where the contract work to be performed requires longitudinal movement of the work area, each subsequent installation of a Standard in a new location will be paid for according to Article 109.04. A contiguous lateral movement of the work area causing a change in the location of traffic control devices, but not a longitudinal relocation of the work area, will not be considered a new location or installation.

(c) Measured As Lump Sum. Traffic control and protection required under Standards 701201, 701206, 701306, 701326, 701336, 701406, 701501, 701606, 701601, 701701, and 701801 will be measured for payment on a lump sum basis. Traffic control protection required under Standard 701401 will be measured for payment on a lump sum basis, except as specified under Article 701.07(b). Where the Contractor's operations result in daily changing, or two or more work areas each of which requires traffic control according to one of the above Standards, each work area installation will not be paid for separately, but shall be included in the lump sum price for the type of protection furnished.

- (d) Traffic Control Surveillance will be measured on a calendar day basis.
- (e) When constructing aggregate shoulders with bituminous resurfacing the cost of placing, compacting, maintaining, removing, and disposing of the temporary earth wedge will not be paid for directly, but shall be included in the contract unit prices for the construction items involved, and no additional compensation will be allowed.

**701.08 Basis of Payment.** The basis of payment for traffic control and protection will be as follows:

- (a) Traffic control and protection indicated in Article 701.07(a) will not be paid for as separate items, but the costs shall be considered as included in the contract unit prices for the construction items involved, and no additional compensation will be allowed.
- Traffic control and protection indicated in Article 701.07(b) will be paid for at the contract unit price each for TRAFFIC CONTROL AND PROTECTION STANDARD 701316, TRAFFIC CONTROL AND PROTECTION STANDARD 701331, **TRAFFIC** CONTROL AND **PROTECTION** STANDARD TRAFFIC CONTROL AND 701401. PROTECTION STANDARD TRAFFIC CONTROL AND **PROTECTION** 701421. CONTROL STANDARD 701431, **TRAFFIC** AND **PROTECTION** STANDARD 701321, TRAFFIC CONTROL AND PROTECTION 701416, and TRAFFIC CONTROL AND PROTECTION STANDARD 701411, at the

The replacement of any temporary pavement marking which has been in place for 7 days or more will be paid for according to Article 109.04.



location specified.

In the event the total value of the work items for which a traffic control Standard is required, is increased or decreased by more than 10 percent, the unit price bid for that Standard will be adjusted as follows:

Adjusted unit price = .25P + .75P (1 + (X - 0.1))

Where P is the bid unit price for the Standard

Where x = Difference between original and final value of Work
Original value of work requiring the use of the Standard

Where (X - 0.1) is 0 if X is less than 0.1.

The value of the work items used in calculating the increase or decrease will include only items which have been added to or deducted from the contract under Article 104.02 and only items which require use of the Standard.

When the plans require multiple locations for the Standard and the Method of Measurement is on an each basis, the adjustment shall only be applied

to the location(s) where added work is required.

(c) Traffic control and protection indicated in Article 701.07(c) will be paid for at the contract lump sum price for TRAFFIC CONTROL AND PROTECTION STANDARD 701201: **TRAFFIC** CONTROL AND PROTECTION STANDARD 701206: **TRAFFIC** CONTROL AND PROTECTION STANDARD 701306: TRAFFIC CONTROL AND PROTECTION STANDARD 701326; TRAFFIC CONTROL AND PROTE CTION STANDARD 701336; TRAFFIC CONTROL AND PROTECTION STANDARD 701406: **TRAFFIC** CONTROL AND **PROTECTION** STANDARD 701401: **TRAFFIC PROTECTION** CONTROL AND STANDARD 701501: TRAFFIC CONTROL AND **PROTECTION** STANDARD 701606: TRAFFIC CONTROL AND PROTECTION STANDARD **TRAFFIC** CONTROL AND **PROTECTION** 701601: STANDARD 701701; or TRAFFIC CONTROL AND PROTECTION STANDARD 701801.

Any alterations (additional or replacement of temporary pavement markings, or increases or decreases in work items by more than 10 percent for which a traffic control standard is required) will be paid for as specified in Article 701.08(b).

(d) Temporary signals required for Standards 701316 and 701321 will be paid for separately at the contract unit price each for TEMPORARY BRIDGE TRAFFIC SIGNALS.

When the Department furnishes the controller for Standards 701316 or 701321 the temporary bridge traffic signals will be paid for at the contract unit price each for TEMPORARY BRIDGE TRAFFIC SIGNALS (STATE FURNISHED CONTROLLER).

Any relocation of the traffic signal equipment due to stage construction changes will not be paid for separately, but shall be included in the cost of the initial installation.

Temporary concrete barrier and end sections will be measured and paid for according to Section 704.



Sand module impact attenuators, temporary bridge rail, and temporary rumble strips will be paid for separately.

- (e) Traffic Control Surveillance will be paid for at the contract unit price per calendar day or fraction thereof for TRAFFIC CONTROL SURVEILLANCE. The cost of the materials for the maintenance of traffic control devices shall be included in the various control pay items.
- (f) Should the Engineer require additional signs, flaggers, barricades or other traffic control devices over and above those specified, they will be paid for according to Article 109.04.

When the Contractor requests a change in the traffic control, any additional flaggers required will be at the Contractor's expense.



## SECTION 702. WORK ZONE TRAFFIC CONTROL DEVICES

**702.01 Description.** This work shall consist of furnishing, maintaining, and removing traffic control devices.

**702.02 Materials.** Materials shall be according to the following Articles of Section 1000 - Materials:

	Item	Article/Section
(a)	Reflective Sheeting	1084.02
(b)	Construction and Maintenance Signs	1084.04

## 702.03 Channeling Devices.

(a) General. Only the name and telephone number of the agency, Contractor, or supplier may be shown on the nonretroreflective surface of all channelizing devices. The letters and numbers shall be a nonretroreflective color and not over 50 mm (2 inches ) in height.

Barricades, drums, cones, and/or vertical panels used for channelization or delineation along with warning signs shall be sequentially placed in the direction of the traffic flow and removed in reverse order. Lane closure and flagger signs shall be erected prior to barricades, drums, cones, and/or vertical panels and remain erected until all traffic control devices have been removed from the pavement.

All barricades, wing barricades, and vertical panels shall have alternating reflectorized white and reflectorized orange strips sloping downward at 45 degrees toward the side on which traffic will pass. Barricade stripes shall be 150 mm (6 inches) in width on barricades 900 mm (36 inches) or greater in length and 100 mm (4 inches) in width on barricades less than 900 mm (36 inches) in length. Type I and Type II Barricades shall be striped on both sides. Wing and Type III Barricades shall be striped on both sides where traffic approaches from either direction. Vertical panels placed on the outside of curves shall be striped on both sides. The predominant color for other barricade components shall be white, orange, or silver, except that galvanized metal or aluminum components may be used.

The lights on wing barricades, barricades, drums, or vertical panels shall be mounted above the top of the device to the side on which traffic will pass and shall not obscure any reflectorized portion of the device.

Cones, drums, and barricades shall not be mixed in individual runs of devices.

(b) Barricades. Type 1 and 1A Barricades are for use on lower speed roads and shall not be used where normal posted speeds are greater than 40 mph unless the reflective area of the upper rail is at least 0.18 m<sup>2</sup> (288 sq. inches). Type I and Type II Barricades shall not be intermixed within an individual string of barricades. Type III barricades shall be used for road and lane closures.

Weights of concrete, stone, wood, or brick will not be allowed and all

weights used to stabilize barricades, other than sandbags, must be rigidly attached to the legs of the barricades as close to the ground as possible. No sandbags will be allowed on the top rail of barricades. Sandbags may be placed on barricade legs, over striped bottom rails not facing traffic, over unstriped bottom rails, or suspended from the barricade rail or frame in such a manner so the bulk of the sand is at least 450 mm (18 inches) below the top of the barricade. Drums may be weighted internally with no more than enough sand or water to provide stability, or by other ballast system designed by the drum manufacturer and approved by the Department.

Barricade and wing barricade rails shall be no heavier than 25 mm (1 inch) thick lumber or plywood except for the sawhorse design Type 1A Barricade which may have a rail no heavier than 50 mm (2 inch) thick lumber. Other light weight weather resistant materials such as plastic, fiberglass, or sheet aluminum may be used. The face of the barricade rails may be sloping or vertical. Nominal lumber dimensions may be used to satisfy wooden barricade component dimensions.

For wing barricades, the optional back bracing on the wood or metal barricade may be used provided it attaches to the upright no higher than 300 mm (12 inches) above the bottom and if wood is used, the bracing shall be no heavier than 50 x 100 mm (2 x 4 inches) in size. Other light weight designs may be used with the approval of the Engineer.

Frames for Type I or Type II Barricades shall be designed to provide a stable support and should be constructed of light weight steel or aluminum angles, tubing, wood, plastic, or rubber and have no rigid stay bracing for "A" frame designs.

- (c) Vertical Panels. Vertical panels may be either post mounted, frame supported or attached to the top of a barrier. Post mounted vertical panels shall be firmly attached to light weight wood or metal posts with the top a minimum height of 1.2 m (4 ft.) above the pavement surface. The frame and rail requirements for Type I and Type II barricades shall also apply to frame supported vertical panels. Frame supported vertical panels shall be used only where normal posted speeds are 40 mph or less with the top of the panel a minimum of 900 mm (36 inches) above the pavement.
- (d) Cones. Reflectorized cones are not required for day light operations, and shall only be used as specified on the plans or as approved by the Engineer. When used, reflectorized cones shall have 2 white reflective bands. Cones shall be constructed of durable material able to withstand abuse by vehicular traffic. Minimum weights shall be 2 kg (4 lbs.) for 450 mm (18 inches), 3 kg (7 lbs.) for 700 mm (28 inches), and 5 kg (10 lbs.) for 900 mm (36 inches) cones with a minimum of 60 percent of the total weight in the base. Where posted speeds are greater than 40 mph cones shall be a minimum of 700 mm (28 inches) in height.
- (e) Drums. Drums shall be nonmetallic and have alternating reflectorized orange and reflectorized white horizontal, circumferential stripes. There shall be at least 2 orange and at least 2 white stripes on each drum. If nonreflective spaces are left between the orange and white stripes, they shall be no more than 50 mm (2 inches) in width. All nonreflectorized portions of the drums shall be orange. Drums may be slightly conical in

shape and may have one or more flat surfaces to minimize rolling when hit. Drums shall have closed tops that shall prevent the collection of roadwork debris. Drums shall be weighted in a manner approved by the manufacturer so they are not moved by wind or traffic.

On construction projects where the ADT exceeds 25,000, plastic drums according to Standard 702001 with steady burning lights shall be used in lieu of Type I and Type II barricades throughout lane closures. They shall be placed at the location and spacing shown on the applicable traffic control standards.

Where plastic drums are specified, Type II barricades may be used in lieu of drums provided the barricades are made of plastic, fiberglass, or other nonmetallic materials, the top panels are 300 mm x 600 mm (12 x 24 inches); the bottom panels are 200 mm x 600 mm (8 x 24 inches), the orange and white reflective sheeting is Type A meeting the initial minimum coefficient of retroflection in Article 1084.02, and all other requirements for Type II barricades are met. If flashing or steady burning lights are required for drums, this requirement shall be extended to the Type II barricades. Drums and Type II barricades shall not be intermixed within an individual taper or string of devices. This does not prohibit drums from being used in a taper section with Type II barricades being used in the tangent section, or vice versa.

(f) Flexible Delineators. Flexible delineators shall be designed to bend under repeated impacts and return to an upright position without damage to the impacting vehicle or the delineators. They shall be attached to the pavement with adhesive meeting the recommendations of the delineator manufacturer. The use of studs will not be permitted without the approval of the Engineer.

The delineators shall be orange in color and have 2 reflectorized orange and 2 reflectorized white bands according to Article 1084.02.

The delineators shall be readily removable from the bases to permit field replacement. All missing or severely damaged delineators shall be replaced prior to suspension of work each working day and once each nonworking day on a schedule approved by the Engineer.

**702.04 Lights.** Flashing lights shall be installed above the first 2 warning signs on each approach to the work involving a nighttime lane closure. These units shall operate during hours of darkness. The Contractor shall be responsible for replacing lighting units which have become defective. The Contractor shall replace all barricade light batteries on a group basis at such times as may be specified by the Engineer.

Barricades or drums with lights shall be used in lieu of cones for night operations. Lights are not required on drums or barricades for day operations. Drums or barricades utilized to protect obstacles, hazards, or excavations at night shall have flashing lights. If the protected area exceeds 30 m (100 ft.) in length, steady burning lights shall be substituted for flashing lights. Drums and barricades for channelizing traffic and tapers shall have steady burning lights. All barricade lights shall be bi-directional except lights on taper barricades, which shall be monodirectional.

## 702.05 Signs.

(a) General. Sign posts may be 100 x 100 mm (4 x 4 inches) wood posts according to Article 1093.01 or metal posts according to Sections 1006 or 1007. Galvanizing of metal posts will not be required. Alternate designs and or materials may be permitted when approved by the Engineer.

Signs on temporary supports shall be within 20 degrees of a vertical position. Weights of concrete, stone, or brick will not be allowed and all weights used to stabilize signs other than sandbags must be rigidly attached to the sign support as close to the ground as possible.

Post mounted signs shall be erected and maintained within 5 degrees of a vertical position. Two posts shall be used for signs greater than 1.5 m $^2$  (16 sq. ft.) in area or where the height between the sign and the ground exceeds 2.1 m (7 ft.). Bracing no heavier than 50 x 100 mm (2 x 4 inch) wood may be used for added support. Any brace placed parallel to the road shall be sloped down toward approaching traffic.

When approved by the Engineer, skids may be used to support signs where posts are impractical. They shall not exceed the structural design of Type III barricades and shall be no greater than 1.2 m (4 ft.) in length.

Where construction operations result in a temporary drop-off at the edge of a completed stabilized shoulder and the road has a posted speed limit of 55 mph or greater and is open to traffic, "SHOULDER DROP-OFF" (W21-I103) signs shall be used. The Contractor shall place the signs at the beginning of the dropoff area, just beyond freeway interchanges or major intersections on nonfreeways, and at such other locations within the dropoff area as the Engineer may direct to ensure a nominal spacing of 3 km (2 miles). The signs shall be placed just prior to the work which will result in the drop-off and shall remain in place until the drop-off is eliminated. This work shall be considered as included in the contract unit prices for the construction items involved and no additional compensation will be allowed.

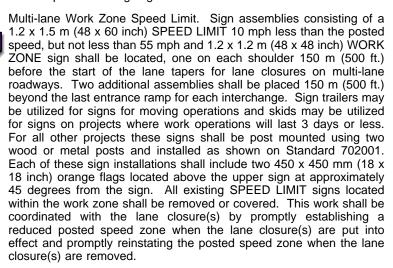
When work operations exceed 4 days, all signs shall be post mounted unless the signs are located on the pavement or defining a moving or intermittent operation. Signs located on the pavement shall be skid mounted. Longitudinal dimensions shown on the plans for the placement of signs may be increased up to 30 m (100 ft.) in order to avoid obstacles, hazards, or to improve sight distance, when approved by the Engineer. ROAD CONSTRUCTION AHEAD signs will also be required on the side roads located within the limits of the mainline ROAD CONSTRUCTION AHEAD signs.

- (b) Arrow Boards. On roads with speeds of 45 mph and above, Type C units shall be used for all operations 24 hours or more in duration, and Type B units may be used for operations less than 24 hours in duration. Type A, B, or C units may be used for all operations on roads with speeds less than 45 mph. Arrow boards shall not be used to direct passing moves into lanes used by opposing traffic or to shift traffic without having a lane change.
- (c) Construction Speed Limit Sign. The sign assembly shall be trailer mounted according to Article 1106.04. All signs shall be reflectorized meeting the

requirements of Article 1084.02. The signs may be combined on a single panel.

The flashing lights for the construction speed limit signs shall feature monodirectional amber lenses with reflectors and shall be visible through a range of 120 degrees when viewed facing the sign. The light shall be either strobe, halogen, or incandescent lamps, be visible for a minimum distance of 1.6 km (1 mile), and have a minimum flash rate of 40 per minute. A small flashing "on" indicator light shall be provided on the back of the sign visible for 150 m (500 ft.) to provide confirmation to workers the light is operating. The lights shall operate on either full battery power with solar panel charging (capable of maintaining a charged battery level) and 135 amp, 12 volt deep cycle battery(s), or a gasoline or diesel powered generator with a maximum fuel capacity of 95 L (25 gals).

(d) Work Zone Speed Limit Signing.



One 750 mm x 1.2 m (30 x 48 inch) END WORK ZONE SPEED LIMIT sign shall be located at the end of the lane closure. If the lane closure terminates at the end of the project, then this sign replaces the END CONSTRUCTION sign, if it is required.

(2) Construction Speed Limit Signing. Two sign assemblies shall be located one on each shoulder for multi-lane roadways where the median is at least 3 m (10 ft.) wide. When specified on other roadways, one device will be required on the right shoulder for each direction of traffic. Additional assembly(s) shall be placed 150 m (500 ft.) beyond the last entrance ramp for each interchange and at each side road(s).

One of these sign assemblies shall be positioned adjacent to the closed lane at a distance of 150 m (500 ft.) minimum to 750 m (2500 ft.) maximum in advance of any worker(s) throughout the length of the lane closure and as directed by the Engineer. The signs shall be

installed on trailers according to Article 1106.04. Care should be used in adjusting the position of these signs in relation to other signs and devices. The sign locations are approximate and should be adjusted to allow approximately 150 m (500 ft.) spacings between these signs and other signs. They should be positioned in such a manner that all motorists approaching a worker(s) shall have an unobstructed view of one or more of these signs.

The speed limit shown shall be 10 mph below the posted or work zone speed limit.

When the Construction Speed Limit sign assembly is used, the END WORK ZONE SPEED LIMIT sign shall be erected at the end of the lane closure. If the lane closure terminates at the end of project, then the END WORK ZONE SPEED LIMIT sign replaces the END CONSTRUCTION sign, if it is required.

The flashing lights shall be activated ONLY when workers are present in a closed lane adjacent to one open to traffic and as directed by the Engineer. At all other times, the lights shall be turned off and the Construction Speed Limit sign assembly shall be promptly removed or covered. When both the Work Zone and Construction Speed Limit signs are no longer in effect the END WORK ZONE SPEED LIMIT sign shall be removed or covered and the posted speed shall be promptly reinstated.

The CONSTRUCTION SPEED LIMIT sign assemblies will not be required when the worker(s) are located behind a concrete barrier wall.

(e) Flagger Traffic Control Paddle. This sign shall be used by the flagger in lieu of flags or other signaling devices. The "STOP" face shall consist of white letters and border on a red retroreflectorized background. The "SLOW" face shall consist of black letters and border on an orange retroreflectorized background. On projects where fluorescent orange diamond shaped warning signs are required, the "SLOW" face shall also be fluorescent orange in color. All reflective faces shall be fabricated with sheeting according to Article 1084.04. Areas outside sign borders shall be light blue or black. The portion of the staff within the sign face shall match the sign colors. All colors and letters shall meet applicable federal standards.

The staff shall consist of 2 sections joined by a coupling located 1.5 m (5 ft.) from the bottom of the staff.

**702.06 Basis of Payment.** This work will not be paid for separately but shall be considered as included in the cost of the traffic control and protection specified in Section 701.

#### SECTION 703. WORK ZONE PAVEMENT MARKING

**703.01 Description.** This work shall consist of furnishing, installing, maintaining, and removing short term and temporary pavement markings.

**703.02 Materials.** Materials shall be according to the following Articles in Section 1000 - Materials:

Item Article	/Section
(a) Pavement Marking Tape	
(b) Painted Pavement Markings	1095.02

#### **CONSTRUCTION REQUIREMENTS**

**703.03 General.** Short term pavement markings shall consist of abbreviated patterns for edge, lane and centerline markings. Within a specified time limit, short term pavement markings shall either be resurfaced or replaced with the full pavement marking patterns indicated on the plans with either a temporary material paid for as temporary pavement marking or with permanent material. Within the conditions as specified, the Contractor may be required to place all or a part of the quantities shown on the plans for short term pavement markings and temporary pavement markings.

The surface to which the pavement marking is to be applied shall be clean and dry. Pavement marking tape shall be applied to the prepared surface according to the manufacturer's recommendations or by a method approved by the Engineer. Painted lines shall be installed according to Section 780 except hand-operated stripers may be used for all applications of short term and temporary pavement marking.

**703.04 Short Term Pavement Markings.** Before the lane is opened to traffic, appropriate Short Term Pavement Markings shall be installed between all lanes open to traffic. Centerline or lane line markings shall consist of an abbreviated pattern of single stripes 1.2 m (4 ft.) in length and a minimum of 100 mm (4 inches) wide at a maximum spacing of 12 m (40 ft.) between stripes. Centerlines on 2-lane highways shall be yellow and lane lines separating 2 or more lanes of traffic moving in the same direction shall be white. Edge line markings will consist of 1.2-m (4-ft.) stripes on 30-m (100-ft.) centers installed at approximately a 45° diagonal pointing in the direction of traffic. Edge line markings will only be required on multilane divided highways and other highways with a paved shoulder greater than 1.2 m (4 ft.) wide. Markings on the final wearing surface shall be transversely offset from the permanent pavement marking location as directed by the Engineer. Markings shall be removed within 5 days after the permanent pavement markings are installed.

The short term pavement markings shall be replaced with the required full standard pavement markings consisting of either temporary or permanent pavement marking as soon as possible. Except as indicated below, temporary pavement marking or the permanent pavement markings shall be installed for no passing zones within 3 calendar days and for all other markings within 14 calendar days, respectively, after the completion of any intermediate or final surface treatment. This time restriction shall begin at the completion of each intermediate or final lift on resurfacing projects.

If the existing markings are obliterated by milling or any other surface treatment, the time restriction shall begin when the entire surface has been treated. These restrictions may be delayed by the Engineer whenever the Contractor cannot apply pavement markings due to unanticipated inclement weather (other than winter shutdown on the project), strike activities, or other circumstances beyond the Contractor's control as determined by the Engineer. In these cases, the required full

standard temporary or permanent markings shall be installed as soon as construction activities are resumed. Prior to winter shutdown, standard edge lines, lane lines, centerlines, no passing zones, and any other necessary markings as determined by the Engineer shall be installed on any intermediate or final surface remaining open to traffic during the winter shutdown period.

**703.05 Temporary Pavement Marking.** When any intermediate course cannot be overlayed or if the final surface cannot be permanently marked within the time restrictions listed above, the full standard markings shall be installed with temporary pavement marking. The temporary markings shall be of the same color and dimensions as shown on the plans for the permanent markings, or as directed by the Engineer.

Type I or Type II marking tape or paint shall be used at the option of the Contractor, except paint shall not be applied to the final wearing surface unless authorized by the Engineer for late season applications where tape adhesion would be a problem. Type III marking tape shall be used on the final wearing surface when the temporary pavement marking will conflict with the permanent pavement marking such as on tapers, crossovers and lane shifts.

Except during winter shutdown periods, temporary pavement marking showing deterioration for any reason within 7 days after placement, shall be replaced by the Contractor at his/her own expense. Temporary pavement markings which are in conflict with subsequently established pavement markings, or which interfere with the permanent pavement markings, shall be removed. Marking tape or paint placed on the final wearing course shall be transversely offset from the permanent pavement marking planned location as directed by the Engineer. All remaining temporary pavement marking tape or paint shall be removed within 5 working days after placement of the permanent pavement marking. When edge lines or channelizing lines are required, they shall be continuous. When continuous sections of tape are used, they shall be cut completely through at intervals of approximately 8 m (25 ft.).

Instead of pavement markings, no passing zones on 2-lane and 3-lane roads may be identified by either the pennant NO PASSING ZONE warning sign or both the DO NOT PASS and PASS WITH CARE regulatory signs in conjunction with Short-Term Markings for periods of time up to 3 calendar days after an intermediate or final lift is completed on resurfacing projects.

These signs may also be used in lieu of pavement markings on low volume roads until it is practical and possible to install the permanent pavement markings.

If, in the traffic control plan, the road is specified as low volume, it is exempt from the requirements regarding no-passing zone pavement markings.

**703.06 Method of Measurement.** Short term pavement markings and temporary pavement markings of the various line widths will be measured for payment in meters (feet) in place and accepted. Double yellow lines will be measured as 2 separate lines.

The replacement of temporary pavement markings of the various line widths during winter shutdown periods will be measured for payment in meters (feet) as specified above, except only those pavement markings directed by the Engineer to be replaced will be measured for payment.

Letters and symbols used in conjunction with temporary pavement marking

conforming to the sizes and dimensions specified will be measured for payment in square meters (square feet) according to the areas listed in Table 1, Section 780.

Short term and temporary pavement marking removal will be measured in square meters (square feet).



**703.07 Basis of Payment.** This work will be paid for at the contract unit price per meter (foot) for SHORT TERM PAVEMENT MARKING or for TEMPORARY PAVEMENT MARKING of the line width specified, and at the contract unit price per square meter (square foot) for TEMPORARY PAVEMENT MARKING LETTERS AND SYMBOLS. Removal will be paid for at the contract unit price per square meter (square foot) for WORK ZONE PAVEMENT MARKING REMOVAL.



## **SECTION 704. TEMPORARY CONCRETE BARRIER**

**704.01 Description.** This work shall consist of furnishing, placing, maintaining, relocating and removing precast concrete barriers at temporary locations as shown on the plans or as directed by the Engineer.

**704.02 Materials.** All materials shall be according to the following Articles of Section 1000 - Materials.

	item .	Article/Section
(a)	Portland Cement Concrete	1020
(b)	Reinforcement Bars	1006.10
(c)	Welded Wire Fahric (Note 1)	1006 10

Note 1. Welded wire fabric shall be 150 x 150, 5.7 mm diameter (6 x 6, W4 x W4) weighing approximately  $2.8 \text{ kg/m}^2$  (58 lbs. per 100 sq. ft.).

#### CONSTRUCTION REQUIREMENTS

**704.03 General.** Precast barrier units shall be constructed according to the applicable portions of Sections 504 and 1020. Precast units shall not be removed from the casting beds until a flexural strength of 2 MPa (300 psi) or a compressive strength of 10 MPa (1400 psi) is attained. Transportation of precast sections to the jobsite will not be allowed until a flexural strength of not less 4.5 MPa (650 psi) or a compressive strength of not less than 24 MPa (3500 psi) is attained. In no case may precast units be loaded, shipped, and used prior to 4 days after casting.

The wall units shall be reinforced with either deformed bar reinforcement or welded wire fabric according to the details shown on the plans. The inserts for M12 (1/2") bolts shall be capable of 13 kN (3000 lbs.) pull-out strength and shall be furnished with a galvanized bolt and washer.

The Contractor shall have the option of furnishing the barrier units with or without the longitudinal keyway.

The temporary barriers shall be removed when no longer required by the contract.

**704.04 Barrier Markings.** Each unit of precast barrier shall be clearly marked with the name or trademark of the manufacturer, the Illinois Department of

Transportation standard and subscript number (i.e. 705001-) and the date of manufacture. If the manufacturer has more than one plant, the plant identification shall also be included. The markings shall be indented on the barrier section or painted thereon with waterproof paint.

**704.05 Configuration.** Precast units which have the New Jersey configuration and which have previously been cast meeting earlier Department standards, may be used. The units shall be in good condition, without cracks or spalls, and the connection devices shall not be broken. The Contractor will be allowed to mix barrier units of previous designs in the same run with new units, provided the connection devices are compatible and the units are of the same width so a smooth, continuous face can be obtained.

Units of other designs from other agencies having the New Jersey configuration may be used with the approval of the Engineer. The Contractor will be required to furnish a certification signed by a responsible official of the outside agency stating the barrier design is currently acceptable and has been inspected and approved by them.

**704.06 Installation.** Barrier units shall only be installed to deflect traffic. Gaps in the barrier shall not be permitted. Barrier shall remain in place until the hazard no longer exists, and then should be removed completely. Each successive set of barriers shall be equipped with tapers for each direction of approaching traffic.

Barrier units shall be placed and pinned together in a continuous smooth line at the exact locations provided by the Engineer. The connecting pin for the pin and loop connection, may be either a plain 22-mm (7/8-inch) diameter or a deformed No. 25 (No. 7) bar meeting the requirements of Article 1006.10(b) except Grade 400 (Grade 60) bars shall be used.

Barrier units or attachments damaged during transportation or handling, or by traffic during the life of the installation, shall be repaired or replaced by the Contractor at his/her expense. The Engineer will be the sole judge in determining which units or attachments require repair or replacement.

The barrier units shall be seated with styrofoam pads except when specified in the plans to be secured with dowel bars. The dowel bars shall be 25 mm (1-inch) in diameter, at least 300 mm (12 inches) long, shall be embedded at least 200 mm (8 inches) into the underlying roadway structure and shall not project above the outer surface of the barrier. After dowel bar removal, all holes in the roadway structure shall be filled with a material approved by the Engineer.

When the temporary concrete barrier terminal section is used it shall be secured to the underlying roadway structure with a drift pin. The hex nut on the drift pin shall be threaded half way onto the pin and tack welded, or coupling nut tightened sufficiently to prevent loosening may be used. The nut shall then be filled with grease to exclude contaminants. After drift pin removal, the hole in the roadway structure shall be filled with a material approved by the Engineer.

When temporary concrete barriers are to be relocated, the units shall be removed from the old location, transported to the new location, and reinstalled as previously specified.

**704.07 Method of Measurement.** Temporary concrete barrier will be measured for payment in meters (feet) in place along the centerline of the barrier.

Terminal sections will be measured as units of each. When stage construction requires barriers to be relocated within the limits of the jobsite, the relocated temporary concrete barrier, including terminal sections, will be measured for payment in meters (feet) in place along the centerline of the barrier and terminal sections.

**704.08** Basis of Payment. When the Contractor furnishes the barrier units, this work will be paid for at the contract unit price per meter (foot) for TEMPORARY CONCRETE BARRIER or RELOCATE TEMPORARY CONCRETE BARRIER and at the contract unit price each for TEMPORARY CONCRETE BARRIER TERMINAL SECTION.

When the Department furnishes the barrier units, this work will be paid for at the contract unit price per meter (foot) for TEMPORARY CONCRETE BARRIER, STATE OWNED or RELOCATE TEMPORARY CONCRETE BARRIER, STATE OWNED, and at the contract unit price each for TEMPORARY CONCRETE BARRIER TERMINAL SECTION, STATE OWNED.

#### SECTION 705. TEMPORARY STEEL PLATE BEAM GUARDRAIL

**705.01 Description.** This work shall consist of furnishing, erecting, maintaining, and removing steel plate beam guardrail, including posts and traffic barrier terminals.

**705.02 Materials.** Materials shall be according to the following Articles in Section 1000 - Materials:

	Item	Article/Section
(a)	Rail Element Plates, End Section Plates, an	d Splice Plates 1006.25
(b)	Bolts, Nuts, Washers and Hardware	1006.25
(c)	Wood Posts and Wood Block	1007.01, 1007.02, 1007.06
(d)	Steel Posts, Blockouts, Restraints, and Wire	Rope for Guardrail 1006.04
(e)	Preservative Treatment	1007.12
(f)	Hollow Structural Tubing	1006.27(b)

### **CONSTRUCTION REQUIREMENTS**

**705.03 General.** Construction of the temporary steel plate beam guardrail and temporary traffic barrier terminals shall be according to the applicable requirements of Sections 630 and 631, respectively.

The guardrail shall be removed after use and shall become the property of the Contractor.

**705.04 Method of Measurement.** Temporary steel plate beam guardrail will be measured for payment in meters (feet). The length measured will be the overall length of rail erected, measured along the top edge of the rail elements to the limits shown on the plans.

The various types of temporary traffic barrier terminals will be measured for payment complete in place in units of each. The pay limit between the terminal and the adjacent guardrail shall be as shown on the plans.

# Art. 705.05 Temporary Steel Plate Beam Guardrail

705.05 Basis of Payment. This work will be paid for at the contract unit price per meter (foot) for TEMPORARY STEEL PLATE BEAM GUARDRAIL of the type specified and at the contract unit price each for TEMPORARY TRAFFIC BARRIER TERMINAL of the type specified. The Contractor, in preparing his/her bid prices shall take into consideration the salvage value of the removed materials.

#### SIGNING



## **SECTION 720. SIGN PANELS AND APPURTENANCES**

**720.01 Description.** This work shall consist of furnishing, fabricating, and/or installing sign panels, complete with sign faces, legend, and supplemental panels.

**720.02 Materials.** Materials shall be according to the following Articles of Section 1000 - Materials

Item Article	Section (
(a) Sign Base	1090
(b) Sign Face	
(c) Sign Legends and Supplemental Panels	1092

The sign mounting support channel shall be manufactured from steel or aluminum.

Steel support channels shall be according to ASTM A 5.25 (mild strip) and Standard 720001 and shall be galvanized. Galvanizing shall be according to ASTM A 525, Coating Designation 90 when galvanized before forming and AASHTO M 232, Class B 2 when galvanized after forming.

Aluminum support channels shall be according to ASTM B 308M, Alloy 6061-T6 or ASTM B 221M, Alloy 6063-T6.

The stainless steel banding for mounting signs or sign support channels to light or signal standards shall be according to ASTM A 167 Type 302B, Grade 18-8 stainless steel.

**720.03 General.** The three types of individual panels are defined by surface area according to the following descriptions:

Type 1 - 0.8 m<sup>2</sup> (9 sq. ft.)

Type 2 Over 0.8 m<sup>2</sup> (9 sq. ft.) and less than 2.2 m<sup>2</sup> (24 sq. ft.)

Type 3 - 2.2 m<sup>2</sup> (24 sq. ft.)

The surface area is determined by calculating the area of the smallest rectangle, measured from edge-to-edge (horizontally and vertically), that will circumscribe an individual sign, except in the case of a triangular sign. The area of a triangular sign shall be the net triangular area.

A sign panel assembly is composed of one or more sign panels mounted individually or as a group. The two types of sign panel assemblies are defined by the total surface area of the individual sign panels according to the following descriptions:

Type A Assemblies are composed of Type 1 sign panels with a total sign panel area of 0.8 m<sup>2</sup> (9 sq. ft.) or less.

Type B Assemblies are composed of Type 1 or Type 2 sign panels with a total sign panel area over 0.8 m<sup>2</sup> (9 sq. ft.).

Where any sign legend dimensions shown in the plans conflict with the sign legend manufacturer's recommendations, the dimensions shown in the plans or as determined by the Engineer shall govern.

The backs of all sign panels shall be metal stamped, engraved, etched, or otherwise marked in a manner designed to last as long as the sign face material, in letters and numerals at least 9.5 mm (3/8 inch) but no more than 19 mm (3/4 inch) in height with the month and year of manufacture, the name of the sign manufacturer, and the initials IDOT.

When standard signs designated by letters and numbers are to be furnished, they shall be according to the MUTCD. Detailed drawings of signs with an "I" preceding the sign designation code are available from the Engineer of Operations. Detailed drawings of all other standard signs are available from the Federal Highway Administration (HTO-20), Washington, D.C. 20590.

# **CONSTRUCTION REQUIREMENTS**

**720.04 Installation.** Sign panels shall be installed using all required supporting channels and mounting hardware specified.

All sheet aluminum sign panels and supporting panels shall be mounted to the sign posts or supporting channels with M8 (5/16 inch) stainless steel, zinc, or cadmium plated steel hex head bolts with lock nuts. For design panels 0.84 m $^2$  (9 sq. ft.) or greater in area, flat steel fender washers shall be placed next to the bolt head and the nut. A 3 mm (1/8 inch) thick nylon washer shall be placed between the metal washer and the sign face. For sign panels less than 0.84 m $^2$  (9 sq. ft.) in area, standard steel flat washer shall be placed next to the bolt head and nut. A nylon washer shall be placed between the metal washer and the sign face.

Supporting channels shall be used to brace sign panels mounted permanently on:

- (a) Single posts when the sign width is greater than 900 mm (36 inches).
- (b) More than one post when the distance between the posts is greater than 1.2 m (4 ft.).

Horizontal supporting channels used to brace individual signs shall be located using the mounting holes prepunched in the sign blank.

All bolts and nuts shall have National Coarse Thread (UNC).

When a Type 2 panel is to be installed above or below a Type 3 panel, all materials shall be the same as those used for the Type 3 panel. The Contractor shall use the same type of sign base material and sign legend throughout this work.

When the plans require auxiliary sign panels or route shields to be installed on a Type 3 sign panel, they shall be fabricated using a sign base according to Article 1090.01 and a sign face according to Article 1091.01.

**720.05 Method of Measurement.** Sign panels will be measured for payment according to Article 720.03.

**720.06 Basis of Payment.** This work will be paid for at the contract unit price per square meter (square foot) for SIGN PANEL, of the type specified.

#### **SECTION 721. SIGN PANEL OVERLAY**

- **721.01 Description.** This work shall consist of furnishing, and installing sign panel overlays, complete with reflectorized or nonreflectorized sign face and legend, on existing sign panels.
- **721.02 Materials.** Materials shall be according to the following Articles of Section 1000 Materials:

	Item	Article/Section
(a)	Sign Base	1090
	Sign Face (Note 1)	
	Sign Legends (Note 2)	
(d)	Overlay Panels (Note 3)	1090.01

- Note 1. The sign face shall be Type A.
- Note 2. The legend shall be Type A except when black in color.
- Note 3. The overlay panels shall be 2 mm (0.08 inch) thick.

#### **CONSTRUCTION REQUIREMENTS**

**721.03 General.** The existing sign shall be stripped off the sign legend, and the sign panel overlay and new legend shall be installed on the existing sign base. Ground-mounted sign panels may be taken down or the required work may be done in place. Any sign panel which is removed for overlaying shall be rigidly braced on the backside so the panel shall not flex and damage the overlay while being reinstalled.

The existing legend shall be completely removed, leaving no rivets protruding from the surface of the panel. The overlay shall be applied in vertical panels not more than 1200 mm (48 inches) nor less than 600 mm (24 inches) in width.

Adjacent panels shall be butt-joined with the spaces between joints 2.5 mm (0.10 inches) or less in width. No horizontal joints shall be used except on sign panels over 3.6 m (12 ft.) in height.

The panels shall be securely fastened to the sign with 4.75 mm (3/16 inch) aluminum dome head rivets with aluminum mandrels. All rivets shall be matched to the color of the overlay panel being installed. The rivets shall be placed at 300 mm (12 inch) centers or less along all four edges and in a vertical row down the center of the panel at 600 mm (24 inch) centers or less. The rivets shall be approximately 6 mm (1/4 inch) in from open edges. All rivets shall be placed in the area of the aluminum extrusion panel ridge to prevent dimples in the sign panel overlay.

The sign sizes and legend sizes shown in the plans shall be verified in the field by the Contractor. The Department assumes no responsibility for the accuracy of these measurements. The replacement legend shall be the same size and shall be spaced the same as the existing sign. The Contractor shall be responsible for the correct spacing of any revised legend according to the general freeway signing practices.

Individual signs shall not be out of service for longer than 24 consecutive hours, subject to the following conditions and exceptions:

- (a) No more than one advance guide sign of the sequence of signs on an approach to an interchange shall be out of service at any given time. (These signs are labeled "A" in the plans.)
- (b) Signs labeled "B" may be out of service at the same time as any other signs.
- (c) Signs labeled "C" are considered critical and shall be out of service no more than 6 consecutive hours and shall not be out of service when any "A" sign for the approach is also out of service.
- **721.04 Method of Measurement.** The sign panel overlay will be measured for payment in square meters (square feet). The area used for measurement shall be the actual area of the sign panel overlay.
- **721.05 Basis of Payment.** This work will be paid for at the contract unit price per square meters (square feet) for SIGN PANEL OVERLAY. Replacement of any sign panel hardware broken during removal of a sign panel will be included in the cost of this item.

#### SECTION 722. DEMOUNTABLE SIGN LEGEND CHARACTERS AND ARROWS

- **722.01 Description.** This work shall consist of furnishing demountable legend characters, arrows, symbols, and route shields and installing them on existing sign panels.
- **722.02 Materials.** Materials shall meet the requirements for sign legend specified for Type 3 sign panels, in Table 200-1.

### **CONSTRUCTION REQUIREMENTS**

- **722.03 General.** Each demountable legend unit shall be securely fastened to a previously prepared sign panel.
- **722.04** Basis of Payment. Demountable sign legend characters, arrows, symbols, and route shields will be paid for at the contract unit price each for DEMOUNTABLE LEGEND CHARACTERS AND ARROWS of the sizes specified.
- No extra compensation will be allowed for borders, diagonals, periods, commas, hyphens, or apostrophe. Auxiliary panels will be paid for according to Article 721.05.

#### SECTION 723. INSTALL EXISTING SIGN PANEL

**723.01 Description.** This work shall consist of installing an existing sign panel on a previously erected sign support(s) or sign structure.

#### CONSTRUCTION REQUIREMENTS

- **723.02 General.** The existing sign panel shall be transported by the Contractor to the location specified in the contract and installed on the previously erected sign support(s) or sign structure according to the details shown in the plans or as directed by the Engineer.
- **723.03 Method of Measurement.** This work will be measured for payment in square meters (square feet) according to Article 720.03.
- **723.04** Basis of Payment. This work will be paid for at the contract unit price per square meter (square foot) for INSTALL EXISTING SIGN PANEL.

# SECTION 724. REMOVE, REPLACE AND RELOCATE SIGN PANEL AND SIGN PANEL ASSEMBLY

- **724.01 Description.** This work shall consist of removing, relocating, and/or replacing sign panels and sign panel assemblies with their supports.
- **724.02** Backfill. All holes left from the removal of supports shall be backfilled with suitable material approved by the Engineer. The surface of the filled hole shall be treated to match the surrounding area.

#### 724.03 Removal.

- (a) Sign Panel Assembly. The sign panel assembly shall be removed from the posts, the supporting channels and the entire support(s) shall be completely removed, and all items transported to the location specified in the contract.
  - When the existing sign panel assembly to be removed is to be replaced by a new sign panel assembly, the new assembly shall be completely installed prior to removal of the existing assembly. Duplicate assemblies shall not exist for periods in excess of 24 hours.
- (b) Sign Panels. The sign panel shall be removed completely, including all hardware, and transported to the location specified in the contract.

### 724.04 Relocate.

- (a) Sign Panel Assembly. The sign panel assembly and supporting channels shall be installed or reinstalled on new sign supports using new mounting hardware according to the details shown in the plans. In no case shall the time between the removal of an existing sign panel assembly and its reinstallation be in excess of 45 minutes.
- (b) Sign Panel. The sign panel shall be installed or reinstalled on previously erected sign supports or a sign structure using new mounting hardware according to the details shown in the plans or as directed by the Engineer. Any new sign support brackets or redrilling of existing brackets shall be provided when necessary. In no case shall the time between the removal of an existing sign panel and its reinstallation be in excess of 2 hours, unless authorized in writing by the Engineer.

# Remove, Replace and Relocate Sign Panel and Sign Panel Assembly

Art. 724.05

- **724.05 State Furnished Signs.** When signs are specified to be furnished on the project by the State, the signs will be made available to the Contractor's office upon written request. These signs will be delivered within one week of request and, upon delivery, will become the responsibility of the Contractor.
- **724.06 Method of Measurement.** Sign Panel removal, replacement, and relocating will be measured in square meters (square feet) according to Article 720.03.
- **724.07** Basis of Payment. This work will be paid for at the contract unit price each for REMOVE SIGN PANEL ASSEMBLY of the type specified or per square meter (square foot) for REMOVE SIGN PANEL of the type specified.

When the contract specifies remove and replace the work shall be considered relocation and will be paid for at the contract unit price each for RELOCATE SIGN PANEL ASSEMBLY of the type specified or per square meter (square foot) for RELOCATE SIGN PANEL of the type specified.

#### **SECTION 725. OBJECT MARKER**

- **725.01 Description.** This work shall consist of furnishing and installing an object marker Type 1, Type 2, or Type 3 on a previously erected support.
- **725.02 Materials.** Materials shall be according to the following Articles of Section 1000 Materials:

		Item A	rticle/Section
ĺ	(a)	Acrylic Plastic Prismatic Center-Mount Reflectors (Note 1)	1097.03
ĺ	(b)	Sign Base	1090
		Sign Face	

Note 1. Used on Type 1 or Type 2 object markers.

**725.03 Basis of Payment.** This work will be paid for at the contract unit price each for OBJECT MARKER - TYPE 1, TYPE 2, OR TYPE 3.

#### SECTION 726. MILE POST MARKER ASSEMBLY

- **726.01 Description.** This work shall consist of furnishing and installing a mile post marker at the location specified in the plans.
- **726.02 Materials.** Materials shall be according to the following Articles of Section 1000 Materials:

		Item	Article/Section
ĺ	(a)	Sign Panel Type 1	1092
ĺ	(b)	Metal Posts and Hardware for Highway Markers,	
İ	` ,	Signs and Delineators	1006.29
İ	(c)	Sign Face	1091

**726.03** Basis of Payment. This work will be paid for at the contract unit price each for MILE POST MARKER ASSEMBLY.

### TABLE 1 MATERIAL REQUIREMENTS SIGN PANEL TYPE-1\*

Description Component	Reflectorized Sign Face	Reflectorized Sign Face	Nonreflectorized Sign Face
	Reflectorized Sign	Nonreflectorized Sign	Nonreflectorized Sign
	Legend	Legend	Legend
Sign Base	Sheet Aluminum	Sheet Aluminum	Sheet Aluminum
(1090)	(1090.01)	(1090.01)	(1090.01)
Sign Face (1091)	Reflective Sheeting Types A, AA, AP, AZ, BB** or B (1091.01(a))	Reflective Sheeting Types A, AA, AP, AZ, BB** or B (1091.01(a))	Nonreflective Sheeting (1091.01(b)) or Enamel Paint (1091.02)
Sign Legend (1092)	Direct Applied Reflective Sheeting Type A, AA, AP, AZ, BB** or B** (1092.01(a)) or	Direct Applied Nonreflective Sheeting (1092.01(a))	Direct Applied Nonreflective Sheeting (1092.01(a)) or
	Transparent Silk Screen	Opaque Silk Screen	Opaque Silk Screen Inks
	Inks (1092.01(d))	Inks (1092.01(d))	(1092.01(d))

 $<sup>^{\</sup>ast}$  1.8 m (6 ft.) wide or less and 0.8 m² (9 sq. ft.) in area or less  $^{\ast\ast}\text{Only}$  when specified

### TABLE 1 (Continued) MATERIAL RÈQUIREMENTS SIGN PANEL TYPE-2\*

Description Component	Reflectorized Sign Face Reflectorized Sign Legend	Reflectorized Sign Face Nonreflectorized Sign Legend	Nonreflectorized Sign Face Nonreflectorized Sign Legend
Sign Base (1090)	Sheet Aluminum (1090.01) or Bolted Aluminum Extrusions (1090.02) or Plywood** (1090.03)	Sheet Aluminum (1090.01) or Bolted Aluminum Extrusions (1090.02) or Plywood** (1090.03)	Sheet Aluminum (1090.01) or Bolted Aluminum Extrusions (1090.02) or Plywood (1090.03)
Sign Face (1091)	Reflective Sheeting Type A, AA, AP, AZ, BB** or B (1091.01(a))	Reflective Sheeting Type A, AA, AP, AZ , BB** or B (1091.01(a))	Reflective Sheeting (1091.01(a)) or Enamel Paint (1091.02)
Sign Legend (1092)	Direct Applied Reflective Sheeting Type A, AA, AP, AZ or B** (1092.01(a)) or Type A Reflective Sheeting on Flat Frames (1092.01(b)) or Transparent Silk Screen Inks (1092.01(d))	Direct Applied Nonreflective Sheeting (1092.01(a)) or Nonreflective Sheeting on Flat Frames (1092.01(b)) or Opaque Silk Screen Inks (1092.01(d))	Direct Applied Nonreflective Sheeting (1092.01(a)) or Nonreflective Sheeting on Flat Frames (1092.01(b)) or Opaque Silk Screen Inks (1092.01(d))
Supplemental Panels (1092)	Reflective Sheeting Type A**,AA, AP, AZ, B or BB** (1092.01(c))	Reflective Sheeting Type A**, AA, AP, AZ, B or BB** (1092.01(c))	Nonreflective Sheeting (1092.01(c)) or Enamel Paint (1091.02)

<sup>\*</sup>Over  $0.8~\text{m}^2$  (9 sq. ft.) in area or over 1.8~m (6 ft.) wide but less than  $2.2~\text{m}^2$  (24 sq. ft.) \*\*Only when specified

Note: On freeways and expressways, Type 2 panels used for guide, information, or service signing shall have the same sign legend as the Type 3 sign panels.

TABLE 1 (Continued)  MATERIAL REQUIREMENTS  SIGN PANEL TYPE-3*		
Description Component	Reflectorized Sign Face Reflectorized Sign Legend	Reflectorized Sign Face Nonreflectorized Sign Legend
Sign Base (1090)	Bolted Aluminum Extrusions (1090.02)	Bolted Aluminum Extrusions (1090.02)
Sign Face (1091)	Reflective Sheeting Types A, AA, AP, AZ, B or BB** (1091.01(a))	Reflective Sheeting Types A, AA, AP, AZ, B or BB** (1091.01(a))
Sign Legend (1092)	Reflective Sheeting on Flat Frames Types A, AA, AP, AZ (1092.01(b))	Reflective Sheeting on Flat Frames (1092.01(b))
Supplemental Panels (1092)	Reflective Sheeting Types A, AA, AP, AZ, B or BB** (1092.01(c))	Reflective Sheeting Types A, AA, AP, AZ, B or BB** (1092.01(c))

<sup>\* 2.2</sup> m<sup>2</sup> (24 sq. ft.) in area or larger \*\*Only when specified

#### **SECTION 727. SIGN SUPPORT - BREAKAWAY**

- **727.01 Description.** This work shall consist of furnishing and installing galvanized structural steel breakaway sign supports or galvanized hollow structural steel tubular breakaway sign supports and stub posts.
- **727.02 Materials.** Materials shall be according to the following Articles of Section 1000.

	Item /	Article/Section
(a)	Structural Steel	1006.04
(b)	Sign Supports	1093.01
(c)	High Strength Steel Bolts, Nuts and Washers	1006.08

Hollow structural steel tubing shall be according to ASTM A 500 (Grade B) or ASTM A 501.

All other structural steel shapes and plates shall be according to AASHTO M 270M (M270).

Shims shall be fabricated from stainless steel shim stock according to ASTM A 240M (A240), Type 302 or 304.

#### **CONSTRUCTION REQUIREMENTS**

**727.03 General.** Sign locations shall be staked by the Contractor and approved by the Engineer prior to installation of sign supports and structures.

The Contractor and the Engineer together shall determine the exact lengths required before ordering the supports to be fabricated.

Breakaway sign posts and breakaway tubular sign posts shall be according to the plans, and the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals.

The steel sign supports shall be fabricated and inspected according to Articles 505.03 through 505.05 All welding shall be continuous and according to Article 505.04.

All fabrication shall be completed and ready for assembly before galvanizing. No punching or drilling shall be permitted after galvanizing.

The slot and 16 mm (5/8 inch) diameter hole in the web and the fuse plate bolt holes in the flange shall be made before galvanizing. The post flange shall be saw cut after galvanizing and bare metal surfaces shall be coated with an approved zinc solder or zinc-rich paint. These surfaces shall not be coated until the fuse plate is installed and all bolts fully tightened.

After fabrication, the post, fuse plate, base plate, and upper 150 mm (6 inches) of the stub post shall be galvanized by the hot-dip process according to AASHTO M 111.

The sign supports shall be erected in a vertical position on stub posts previously cast into the foundations. The faces of the supports shall be flush with the sign

throughout the contact area. The supports shall be plumbed and brought to final grade.

The top of the supports shall be set within 50 mm (2 inches) of, but not above, the top of the sign when installed at the height specified. When two or more sign supports are required for any sign, the supports shall be erected parallel to each other.

Shims may be used between the plates to level posts.

Posts shall be assembled to stubs with high strength bolts and washers as detailed on the plans.

The bolts in the base plate shall be tightened in a systematic order to the required torque.

Each bolt shall be loosened and tightened to the required torque in the same order as the initial tightening.

Threads at the junction of the bolt and nut shall be burred or center punched to prevent the nut from loosening.

**727.04 Welding.** All welding shall be continuous and according to Article 505.04(r).

**727.05 Tightening.** All friction fuse bolts shall be tightened in the shop as approved by the Engineer and according to the current Specifications of Structural Joints using AASHTO M 164M (M164) bolts and one of the following methods:

- (1) Turn-of-Nut Tightening
- (2) Tightening by use of a Direct Tension Indicator

Tightening shall obtain the following minimum residual tension on each bolt:

Min. Residual	Min. Residual
Bolt Tension	Bolt Tension

Bolt Dia.	kN (lbs.)	Bolt Dia.	kN (lbs.)
M12 (1/2 inch)	50.6 (12,050)	M22 (7/8 inch)	182 (39,250)
M16 (5/8 inch)	94.2 (19,200)	M24 (1 inch)	212 (51,500)
M20 (3/4 inch)	147 (28,400)	M27 (1-1/8 inch)	275 (56,450)
		M30 (1-1/4 inch)	337 (71.700)

- **727.06 Foundations.** Sign support foundations shall be of the type indicated on the plans.
  - (a) Cast-in-Place. Cast-in-Place concrete foundations shall be according to Section 503.
  - (b) Precast. Precast foundations shall be according to Section 504.
- **727.07 Method of Measurement.** This work will be measured for payment in kilograms (pounds) of structural steel sign support erected in place.

The measurement of the structural steel shall be computed on the basis of the mass (weight) per meter (foot) of the support, multiplied by the combined length of the main posts and stub posts.

The measurement of the tubular steel shall be computed on the basis of the Post Mass (Weight) Calibration Table shown on the plans for the main posts installed, plus the mass (weight) of the stub posts.

No allowance will be made for the mass (weight) of the welds, either shop or field, and for the galvanizing.

**727.08** Basis of Payment. This work will be paid for at the contract unit price per kilogram (pound) for STRUCTURAL STEEL SIGN SUPPORT-BREAKAWAY or TUBULAR STEEL SIGN SUPPORT-BREAKAWAY.

All miscellaneous hardware for both the stub post and main post shall be included in the contract unit price bid for the sign support specified. No allowance will be made for overrun and no deduction made for cuts, copes and holes.



#### SECTION 728. TELESCOPING STEEL SIGN SUPPORT

**728.01 Description.** This work shall consist of furnishing and installing telescoping steel sign supports for ground-mounted signs utilizing a telescoping base section or a previously installed cast iron base.

**728.02 Materials.** Materials shall be according to the following Articles of Section 1000 - Materials:

#### CONSTRUCTION REQUIREMENTS

**728.03 General.** The estimated length of a support includes the total length of all required sections. When 2 or more posts support the same sign, they shall be erected parallel to each other with the tops of the posts at the same elevation.

The sign locations shall be staked by the Contractor and approved by the Engineer prior to installation of the posts. The Contractor shall be responsible for the proper elevation, offset, and orientation of all signs as indicated in the plans or as directed by the Engineer.

When the support specified is too long, the Contractor may choose to cut the top section or telescope the top section farther into the base section. Any section cut shall have the cut end completely deburred.

When signs are to be placed on adjacent post sides and the posts have holes in only 2 opposite sides, the Contractor shall drill any additional holes necessary to the tolerances according to Article 1093.01(a)(3).

The top section may be spliced. Splicing shall be done according to the plans and will only be permitted in the upper third of the top section. Only one splice per support will be permitted. The internal splice member shall be 45 mm (1 3/4 inch) by 45 mm (1 3/4 inch).

#### 728.04 Installation Methods.

(a) Pavement Mount. Pavement mounted installation shall be used only in paved areas and shall consist of 3 sections as shown in the plans. The base sections may be installed before or after the paving operation, except a hole no greater than 150 mm (6 inches) in diameter shall be cut in the pavement.

Any pavement removed shall be neatly replaced around the base section with like material to the depth of the original pavement.

The 57 mm (2 1/4 inch) by 57 mm (2 1/4 inch) base section shall be driven by hand or mechanical means to a minimum depth of 850 mm (34 inches) measured from the pavement surface. The top of the base section shall be protected by a suitable driving cap. When required by the Engineer, the earth around the support shall be compacted after driving.

The sleeve section shall be telescoped over the base section or may be driven with the base section as a unit. The tops of both sections shall be at the same elevation, with the bolt holes aligned.

The 50-mm (2-inch) by 50-mm (2-inch) top section shall be telescoped into the base section a minimum of 200 mm (8 inches) and a maximum of 300 mm (12 inches) and the 3 sections fastened together as shown in the plans.

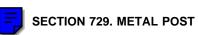
(b) Ground Mount. Ground mounted installations shall consist of 2 sections as shown in the plans. The 55 mm (2 1/4 inch) by 55 mm (2 1/4 inch) base section shall be driven by hand or mechanical means to a minimum depth of 1.5 m (5 ft.) measured from the ground line or as shown in the plans. The top of the base section shall be protected by a suitable driving cap. When required by the Engineer, the earth around the support shall be compacted after driving.

The 50-mm (2-inch) by 50-mm (2-inch) top section shall be telescoped into the base section a minimum of 200 mm (8 inches) and a maximum of 200 mm (12 inches) and the 2 sections fastened together as shown in the plans.

(c) Base Casting. Base casting shall consist of 2 sections as shown in the plans. The base section shall be 57 mm (2 1/4 inch) by 57 mm (2 1/4 inch) by 216 mm (8 1/2 inch). This section shall be inserted at least 170 mm (6 3/4 inches) into the base casting to form a shim into which the 50-mm (2-inch) section is placed. The top section shall be inserted at least 170 mm (6 3/4 inches) into the base casting. After the top section is in place, the installation shall be bolted together as shown in the plans.

**728.05 Basis of Payment.** This work will be paid for at the contract unit price per meter (foot) for TELESCOPING STEEL SIGN SUPPORT. No additional compensation will be allowed for the different sizes in sections, for any pavement patching required, any cutting or deburring of the top section, drilling holes, or telescoping of a top section more than 300 mm (12 inches) into a base section. Payment for the base casting will be made according to Section 731.

Metal Post Art. 729.01



**729.01 Description.** This work shall consist of furnishing Type A and/or Type B metal posts, and installing them utilizing the direct burial method.

**729.02 Materials.** Materials shall be according to the following Article of Section 1000 - Materials:

#### **CONSTRUCTION REQUIREMENTS**

**729.03 General.** The metal posts may be driven by hand or mechanical means to a minimum depth of 1.0 m (3.5 ft.) for Type A or 1.2 m (4.0 ft.) for Type B. The depths shall be measured from the ground line. The post shall be protected by a suitable driving cap and when required by the Engineer, the material around the post shall be compacted after driving.

Scratching, chipping, or other damage to the posts shall be avoided during handling and installation. If chips and/or scratches occur, the areas shall be recoated in the field by a method meeting the coating manufacturer's recommendations. Chips and scratches totaling more than 5% of the surface area of any one post and/or more than 5% of the surface area in any 300-mm (1 ft.) segment of any one post shall be cause for rejection of the post.

When the post specified is too long, the Contractor may choose to cut the post to the required length or increase the embedment. Any post cut shall be installed with the cut end at the bottom.

- **729.04 Method of Measurement.** The metal post will be measured for payment in meters (feet). The length to be measured shall be the total length installed as shown on the plans.
- **729.05 Basis of Payment.** This work will be paid for at the contract unit price per meter (foot) for METAL POST TYPE A or TYPE B. No extra compensation will be allowed for cutting or for increasing the embedment of a post.

#### SECTION 730, WOOD SIGN SUPPORT

- **730.01 Description.** This work shall consist of furnishing and installing nominal 100-mm (4-inch) by 150-mm (6-inch) wood sign supports for ground-mounted signs.
- **730.02 Materials.** Materials shall be according to the following Articles of Section 1000 Materials:

	Item	Article/Section
(a)	Wood	1007
(b)	Preservative Treatment	

#### CONSTRUCTION REQUIREMENTS

**730.03 General.** All 100-mm (4-inch) by 150-mm (6-inch) wood posts shall be modified to satisfy the breakaway requirements by drilling 38 mm (1 1/2 inch) diameter holes centered at 100-mm (4-inches) and 450-mm (18-inches) above the groundline and perpendicular to the centerline of the roadway.

When the support specified is too long, the Contractor may choose to dig the hole deeper or to cut the support to the required length. All cut ends shall become the tops of the supports and shall have the cut end swabbed with a mixture of not less than 5% pentachlorophenol and petroleum solvent before the signs are mounted.

- **730.04 Installation Methods.** The wood sign supports shall be installed with the 150-mm (6-inch) dimension parallel to the adjacent edge of pavement, utilizing one or both of the following methods as specified in the plans.
  - (a) Wood sign supports shall be placed in a vertical hole not exceeding 300 mm (12 inches) in diameter and not less than 1.5 m (5 ft.) deep. The support shall be placed in the center of the hole and backfilled with stone screenings, thoroughly tamped in 300-mm (12-inch) lifts. The stone screenings shall be CA 6, according to Article 1004.01. Not less than 14 days after the placing of the sign assembly on the post, the Contractor shall inspect each installation, and straighten and retamp around each post as required.
  - (b) Concrete Foundation. Wood supports shall be placed in the concrete foundation to a depth of 900 mm (3 ft.). After placement in the foundation, the post shall be shimmed as necessary with wooden wedges inserted between the post and the sides of the foundation so as to securely hold the post in a vertical position to the satisfaction of the Engineer.
- **730.05 Method of Measurement.** Wood sign supports will be measured for payment in meters (feet). The length to be measured will be the total length installed. Any embedment over 150 mm (6 inches) beyond that shown in the plans will not be included for measurement.
- **730.06** Basis of Payment. This work will be paid for at the contract unit price per meter (foot) for WOOD SIGN SUPPORT. No extra compensation will be allowed for any cutting and treating.

Payment for the concrete foundation will be according to Section 734.

#### SECTION 731. CAST IRON BASE FOR TELESCOPING STEEL SIGN SUPPORT

- **731.01 Description.** This work shall consist of furnishing and installing a cast iron base for telescoping steel sign supports.
- **731.02 Materials.** Materials shall be according to the following Articles of Section 1000 Materials:

		Item	Article/Section
İ	(a)	Base for Telescoping Steel Sign Support	
ĺ	(b)	Aluminum Paint	1008

#### CONSTRUCTION REQUIREMENTS

**731.03 General.** Base castings installed on sidewalks or median islands shall be affixed with 3 bolts.

The base casting shall be leveled by using corrosion resistant washers as shims at the anchor bolt locations and under the base casting.

- **731.04 Method of Measurement.** The base castings will be measured for payment in individual units complete in place.
- **731.05 Basis of Payment.** This work will be paid for at the contract unit price each for BASE FOR TELESCOPING STEEL SIGN SUPPORT.

# SECTION 732. PRECAST CONCRETE FOUNDATION FOR WOOD SIGN SUPPORT

- **732.01 Description.** This work shall consist of furnishing and installing a precast reinforced concrete foundation for wood sign supports.
- **732.02 Materials.** Materials shall be according to the following Articles of Section 1000 Materials:

Item	Article/Section
(a) Portland Cement Concrete	1020
(b) Reinforcement Bars	
(c) Coarse Aggregate	1004

#### **CONSTRUCTION REQUIREMENTS**

**732.03 General.** Concrete foundations shall be constructed according to the applicable requirements of Section 734. Foundations shall be placed in a vertical hole at least 150 mm (6 inches) deeper than the length of the foundation. The bottom of the hole shall be covered with enough coarse aggregate to allow the top of the foundation to be a maximum of 75 mm (3 inches) above the ground.

A foundation hole less than 300-mm (12 inches) diameter requires no backfilling or tamping. A hole diameter 300 mm (12 inches) to 375 mm (15 inches) shall be backfilled with sand. A hole diameter exceeding 375 mm (15 inches) shall be backfilled with suitable material approved by the Engineer and tamped in 300-mm (12-inch) lifts.

Reinforcement bars shall be No. 10 (No. 3) and shall be according to Section 508.

**732.04 Basis of Payment.** This work will be paid for at the contract unit price each for CONCRETE FOUNDATIONS FOR WOOD SIGN SUPPORT.

#### **SECTION 733. OVERHEAD SIGN STRUCTURES**

**733.01 Description.** This work shall consist of fabricating, furnishing, and erecting span, monotube, cantilever or bridge mounted type, overhead sign structures including supports on previously prepared foundations and/or installing an overhead sign structure walkway on span or cantilever overhead sign structures.

**733.02 Materials.** Materials shall be according to the sign structure detail sheets included in the plans and the following Articles of Section 1000 - Materials:

Item	Article/Section
(a) High - Strength Steel Bolts, Nuts, and Washers	1006.08
(b) Anchor Bolts	
(c) Fabric Bearing Pads	1082.01
(d) Overhead Sign Structures	

#### CONSTRUCTION REQUIREMENTS

**733.03 Drawings.** Two sets of shop fabrication drawings for each overhead sign structure shall be submitted to the Engineer for approval according to Article 505.03.

**733.04 Fabrication.** Structural steel shall be fabricated and inspected according to the applicable portions of Articles 505.04 and 505.05. Aluminum shall be fabricated according to Article 1094.06 and the following:

Materials shall be sawed or milled. Thermal cutting will not be permitted. Holes in extruded alloys shall be drilled. All holes in castings shall be cored and reamed for final fit. All holes in forgings shall be drilled from solid or formed and reamed for final fit. In handling aluminum materials in the shop and in the field, every precaution shall be taken to avoid scoring and marring of the surfaces, and any such scoring or marring of the surfaces, sufficient in the opinion of the Engineer to give an objectionable appearance, shall be cause for rejection of material. Cast or forged parts shall have all fins or other irregularities removed. Tubing shall be seamless and uniform in quality and temper. Exterior and interior surfaces shall be clean, smooth, and free from seams, slivers, laminations, grooves, cracks, or other defects.

#### 733.05 Reserved.

- **733.06 Surface Treatment of Structural Steel Supports.** Structural steel supports shall be hot dipped galvanized according to AASHTO M 111 after fabrication is completed.
- **733.07 Erection.** Erection of all structural steel and structural aluminum shall be according to the applicable requirements of Article 505.08. High strength bolts, nuts, and washers shall be assembled and tightened according to Article 505.04(f)(3). Following are the requirements for using other bolts:
  - (a) Bolts, nuts, and washers used for assembling the steel or aluminum shall be according to Article 1006.29(d).
  - (b) Stainless steel bolts, nuts, and washers used for assembling the aluminum

truss sections of simple-span structures or fastening aluminum cantilevers to steel columns shall comply with Article 1006.29(d) and the following requirements. Bolt and nut threads shall be cleaned and lightly oiled prior to field assembly. Based on tests of identical assemblies submitted to the Engineer for approval, the installation torque will produce a preload representing 70 to 80% of the material's minimum required yield strength at the thread's cross sectional (tensile stress) area. For ASTM A 193M (A193) Grade B8 or B8M, Class 1 bolts with coarse (UNC) threads, the preload ranges required, as verified by instrumented tests, shall be as follows:

Nominal Diameter <u>mm</u>	Preload Range <u>kN</u>	UNC Bolt Size <u>inch</u>	Preload Range <u>lbs.</u>
M20	36 - 40	3/4	7000 - 8000
M22	44 - 50	7/8	9700 - 11000
M24	51 - 58	1	12700 - 14500
M27	67 - 76	1-1/8	16000 - 18300
M30	81 - 93	1-1/4	20300 - 23200
M36	119 - 135	1-3/8	24200 - 27700

**733.08 Wire Cloth.** The void between the base plate and the foundation shall be enclosed according to the following requirements:

A stainless steel mesh 6 mm (1/4 inch) maximum opening with a minimum wire diameter of 1.5 mm (AWG No. 16) with a minimum 50 mm (2 inch) lap shall be installed to enclose the void between the base plate and the foundation. The stainless steel screen wire shall be formed to the shape of the base plate and fastened to the base plate with 19-mm (3/4-inch) stainless steel banding. The screen wire shall overlap and be fastened with a ring type connection.

**733.09 Field Painting.** Field painting for all exposed steel surfaces not galvanized shall be done according to the plans and the requirements of the latest paint system provisions for structural steel.

#### 733.10 Method of Measurement.

- (a) Sign Structure Span Cantilever or Monotube Span. Cantilever or monotube sign structures, will be measured for payment in meters (feet) from center to center of supports or from end of the unsupported end to center of the support as shown on the plans. The measurement shall include the end supports. For steel or aluminum, three dimensional space frame trusses, the measurement shall include the truss inspection grating inside the truss.
- (b) Sign Structure Bridge Mounted. Bridge mounted overhead sign structures will be measured for payment in meters (feet) of the overall length of the walkway.
- (c) Sign Structure Walkway. The sign structure walkway will be measured for payment in meters (feet) of the overall length of the walkway, end to end.

733.11 Basis of Payment. This work will be paid for at the contract unit price per meter (foot) for OVERHEAD SIGN STRUCTURE - SPAN, OVERHEAD SIGN STRUCTURE - MONOTUBE of the width and depth specified, or OVERHEAD SIGN STRUCTURE - BRIDGE MOUNTED and/or OVERHEAD SIGN STRUCTURE WALKWAY.

#### SECTION 734. CONCRETE FOUNDATIONS FOR SIGN STRUCTURES

**734.01 Description.** This work shall consist of constructing Class SI concrete foundations for the installation of structural steel sign supports and overhead sign structures.

**734.02 Materials.** Materials shall be according to the following Articles of Section 1000 - Materials:

Item	Article/Section
(a) PCC Concrete	1020
(b) Ground Rod	

#### CONSTRUCTION REQUIREMENTS

- **734.03 General.** Concrete foundations of the type and size specified in the plans, shall be constructed according to the applicable requirements of Section 503 and the following:
  - (a) Spread Foundations for Overhead Sign Structures. Unless the contract plans were designed based on actual soil data for the site with specific bearing capacity requirements, the footing shall be placed on cohesive soil having a minimum unconfined compressive strength of 120 kPa (1.25 tons per sq. ft.) as determined by the Engineer. If the bearing capacity does not meet the minimum requirements the foundation design will be re-evaluated. The footings shall be constructed according to the applicable requirements of Article 503.14. Conduit, when specified, shall be installed rigidly in place before the concrete is deposited. The top 100 mm (4 inches) of backfill material shall be topsoil suitable for seeding.

Backfill shall be placed prior to the structural steel support frames. It shall be placed in 100-mm (4-inch) layers and shall be compacted by hand operated mechanical tampers to give a compaction of at least 90 percent of the maximum density shown on the dry weight curve as determined by the Standard Compaction Test. Care shall be taken to prevent damage to the concrete. Backfill shall be brought level to the finished ground line. All areas disturbed by the Contractor's operations shall be seeded according to Section 250.

The anchor bolts shall be firmly held in position by a template during the placing of the concrete.

The top of the foundation shall be finished level, and all exposed surfaces shall be finished according to Article 503.16(a).

(b) Drilled Shaft Foundations for Overhead Sign Structures. The drilling of the

holes shall be accomplished by means of either truck mounted or crane mounted earth augers. The drill unit used shall be such that the shafts can be excavated to the diameters, alignment, and depth required. Material excavated by drilling shall be disposed of by the Contractor outside the limits of the right-of-way.

If boulders or masonry foundations are encountered below natural ground during drilling, the holes shall continue through these obstructions. After drilling operations and excavation for the tie beam have been completed, all loose material existing at the bottom of the hole shall be removed before placing concrete.

The Contractor shall have available a suitable light for the inspection of the drilled hole for its entire depth. All holes will be examined for straightness. Any hole upon visual inspection from the top which shows less than one-half the diameter of the hole at the bottom will be rejected.

Water shall not be permitted to enter the holes, and all water which may have infiltrated into the hole shall be removed before placing concrete. If dewatering of the drilled hole cannot be readily accomplished without loss of ground or creating quick conditions, the hole shall be lined and tremied concrete shall be used.

Suitable casings shall be furnished and placed when required to prevent caving of the hole before concrete is placed. Casings, if used in drilling operations, shall be removed from the hole as concrete is placed. The bottom of the casing shall be maintained not more than 1.5 m (5 ft.) nor less than 300 mm (1 ft.) below the top of the concrete during withdrawal and placing operations, unless otherwise permitted by the Engineer. Separation of the concrete during withdrawal operations shall be avoided by hammering or otherwise vibrating the casing.

The method of placing concrete in the shafts shall be subject to the approval of the Engineer at all times, and the method used shall provide a continuous flow with no segregation of the concrete materials.

The reinforcing cage shall be placed and secured symmetrically about the axis of the shaft and shall be securely blocked to clear the sides of the hole.

- (c) Concrete Foundations for Ground-Mounted Sign Supports. The top segment of these foundations shall be finished according to Article 503.16(a) and formed down to a depth of at least 300 mm (1 ft.) below the ground line, and the concrete shall be finished level at the ground line.
- **734.04 Method of Measurement.** This item will be measured for payment according to Article 503.21.
- **734.05** Basis of Payment. This work will be paid for at the contract unit price per cubic meter (cubic yard) for CONCRETE FOUNDATIONS, or DRILLED SHAFT CONCRETE FOUNDATIONS.

Granular backfill, when required, will be paid for according to Article 109.04.

Seeding will not be measured for payment but will be considered included in this

Art. 734.05

If it becomes necessary to revise the dimensions of the foundations from those shown in the plans, the additional excavating and backfilling, except granular backfill when required, will be considered included in this item.

Rock excavation will be classified and paid for according to Section 502.

When the contract does not contain a unit price for rock excavation for structures and rock is encountered, it will be paid for according to Article 109.04.

# SECTION 735. RELOCATE OVERHEAD SIGN STRUCTURE OR GROUND MOUNTED SIGN SUPPORT

- **735.01 Description.** This work shall consist of removing a span, monotube or cantilever overhead sign structure complete with support(s) and/or a ground mounted sign support, and installing it at another location using either the existing supports or new supports.
- **735.02 Relocation.** The new foundation shall be constructed according to Section 734, and the old foundation shall be removed according to Section 737.
  - (a) Overhead Sign Structure. The complete horizontal section of the overhead sign structure shall be removed from the support(s) and the support(s) removed from the foundation(s). The complete overhead sign structure shall then be transported to its new location and erected according to Section 733, using new nuts and washers on the foundation(s).
  - (b) Ground Mounted Sign Supports. Each support shall be removed from the foundation, transported to its new location, and erected on a foundation.

All materials required for erecting the relocated support, such as mounting hardware, shims, etc., shall be considered as part of the support.

**735.03** Basis of Payment. This work will be paid for at the contract unit price each for RELOCATE OVERHEAD SIGN STRUCTURE - SPAN or CANTILEVER, RELOCATE MONOTUBE OVERHEAD SIGN STRUCTURE - SPAN or CANTILEVER, or RELOCATE GROUND MOUNTED SIGN SUPPORT.

#### SECTION 736. REMOVE OVERHEAD SIGN STRUCTURE

- **736.01 Description.** This work shall consist of removing a span, monotube, cantilever or bridge-mounted overhead sign structure.
- **736.02 Removal.** The entire overhead sign structure, including sign panels and sign lighting, is to be removed from the right-of-way. The removed structure shall be disposed of according to the contract.
  - Concrete foundations shall be removed according to Section 737.
- **736.03 Basis of Payment.** This work will be paid for at the contract unit price each for REMOVE OVERHEAD SIGN STRUCTURE SPAN or CANTILEVER,

REMOVE OVERHEAD SIGN STRUCTURE, MONOTUBE - SPAN or CANTILEVER, or REMOVE OVERHEAD SIGN STRUCTURE - BRIDGE MOUNTED.

# SECTION 737. REMOVE GROUND-MOUNTED SIGN SUPPORT AND/OR CONCRETE FOUNDATIONS

**737.01 Description.** This work shall consist of removing a ground-mounted sign support and/or concrete foundations.

#### 737.02 Removal.

(a) Ground - Mounted Sign Support. The ground-mounted sign support is to be completely removed from the right-of-way within 24 hours after removal of the sign panel. The removed support shall become the property of the Contractor, and any salvage value received shall be reflected in the bid price.

Sign panels shall be removed according to Section 724.

(b) Concrete Foundations. All components of the concrete foundation, including the concrete, reinforcing, stub post, and electrical items, shall be removed at least 300 mm (1 ft.) below the ground line.

The use of explosives of any kind will not be permitted in removing concrete foundations.

The hole shall be backfilled with suitable material approved by the Engineer. The surface of the filled hole shall be treated to match the surrounding area.

Seeding will not be measured for payment but shall be considered as included in this item. Seeding shall be done according to applicable portions of Section 250.

All debris resulting from this operation shall be removed from the right-of-way.

Concrete foundations for overhead sign structures shall be removed within 5 calendar days after the removal of the overhead sign structure.

**737.03 Basis of Payment.** This work will be paid for at the contract unit price each for REMOVE GROUND-MOUNTED SIGN SUPPORT and/or REMOVE CONCRETE FOUNDATION-GROUND MOUNT or OVERHEAD.

# SECTION 738. REMOVE, REPLACE, AND REERECT OVERHEAD SIGN STRUCTURE - SPAN, MONOTUBE, OR CANTILEVER

**738.01 Description.** This work shall consist of removing a sign structure, replacing damaged components and reerecting the overhead sign structure.

Art. 738.02

**738.02 Materials.** Drawings, fabrication, welding of structural steel, surface treatment of structural steel supports, erection, wire cloth, galvanizing and the replacement of nuts, bolts, and washers shall be according to the applicable portions of Section 733.

#### 738.03 Removal.

- (a) Structural Steel Support. The damaged structural steel end support shall be removed, replaced and moved from the right-of-way. The support shall become the property of the Contractor. Any salvage value shall be reflected in the bid price. This work shall also include the removal of an existing sign panel, if one is present, and reinstallation of the same sign panel on the new end support, and the installation of a sign structure number as directed by the Engineer.
- (b) Overhead Sign Structure. The Contractor shall remove the entire overhead sign structure, including sign panels, sign lighting or walkway, from its support(s) and properly anchor the structure on blocks. The entire overhead sign structure shall be reerected, when the structure is reattached to the supports including the replacement of any damaged hardware.

Saddle shim blocks and fabric pads shall remain in their proper position during reerection.

The district where this work is being performed shall be responsible for disconnecting the sign lighting prior to removal of the overhead structure and reconnecting the sign lighting after the overhead structure has been reerected.

**738.04** Basis of Payment. This work will be paid for at the contract unit price each for STRUCTURAL STEEL SUPPORT FOR OVERHEAD SIGN STRUCTURE - SPAN or CANTILEVER. Removing and reerecting the overhead sign structure will be paid at the contract unit price each for REMOVE AND REERECT OVERHEAD SIGN STRUCTURE-SPAN CANTILEVER.

#### **PAVEMENT MARKING**

# SECTION 780. PAVEMENT STRIPING

**780.01 Description.** This work shall consist of furnishing and applying pavement marking.

**780.02 Materials.** Materials shall be according to the following Articles of Section 1000 - Materials:

	Item	Article/Section
(a)	Thermoplastic Pavement Markings	1095
(b)	Painted Pavement Markings	1095
(c)	Preformed Plastic Pavement Markings	1095
	Epoxy Pavement Marking	
	Preformed Thermoplastic Pavement Markings	

**780.03 Equipment.** Equipment shall be according to the following Articles of Section 1100.

	Item	Article/Section
(a)	Thermoplastic Truck Mounted (Note 1	) 1105.01
(b)	Thermoplastic Hand Operated (Note	í) 1105.01
(c)	Epoxy	1105.02

Note 1. A mechanical beader approved by the Engineer shall be used.

#### **CONSTRUCTION REQUIREMENTS**

**780.04 General.** Thermoplastic and epoxy pavement markings shall only be applied by Contractors on the list of Approved Contractors maintained by the Engineer of Operations and in effect on the date of advertisement for bids.

Pavement marking on freeways shall be placed with truck-mounted equipment. Markings on roads other than freeways may be placed with either truck-mounted or hand-operated equipment.

Before applying the pavement marking material, the pavement shall be clean, dry and free of debris or any other material that would reduce the adhesion of the markings on the pavement.

The edge of a center line or lane line shall be offset a minimum distance of 50 mm (2 inch) from a longitudinal crack or joint. Edge lines shall be approximately 50 mm (2 inch) from the edge of pavement. The finished center and lane lines shall be straight, with the lateral deviation of any 3 m (10 ft.) line 25 mm (1 inch) or less.

Pavement marking words and symbols shall conform closely to the dimensions and spacing specified in the MUTCD and the plans. Deviations from the required dimensions and spacing or other departures from reasonable standards of professionalism will be cause for rejection by the Engineer.

The words and symbols shall be as specified in Table 1 in Article 780.12.

**780.05 Thermoplastic.** New thermoplastic material shall not be applied over existing pavement markings. The Contractor shall remove all existing material which may cause premature failure of the new material.

The Contractor shall remove the existing pavement markings prior to applying the thermoplastic pavement markings, the area removed shall be no wider than the width of the existing pavement markings. The new thermoplastic pavement markings shall be applied over the location where the pavement markings were removed.

The compound shall be installed in a molten state at a minimum temperature of 205 °C (400 °F.) and maximum temperature of 245 °C (475 °F.). Scorching or discoloration of material will be cause for rejection by the Engineer. The machinery shall be constructed so all mixing and conveying parts, up to and including the shaping-die, maintain the material in a molten state.

Thermoplastic shall be applied only when the pavement temperature is 13 °C (55 °F.) or greater and no later than November 1 or earlier than April 15. If the thermoplastic markings cannot be placed according to these specifications and the road is to be opened to traffic between November 1 and April 15 and no adequate pavement markings are in place, the Contractor shall, at the direction of the Engineer, place temporary pavement markings according to Section 703. The Contractor shall remove the temporary pavement markings and place the thermoplastic pavement markings on or after April 15 or as agreed upon by the Engineer.

A binder sealer shall be applied on all bituminous pavements over 60 days old and on all pcc pavement surfaces where the new thermoplastic material is to be installed. The binder sealer material shall be applied as recommended by the manufacturer of the thermoplastic and in sufficient quantities to entirely cover the surface on which the thermoplastic is to be laid.

The thermoplastic material shall be applied at a thickness of not less than 2.50 mm (0.100-inch) but no greater than 2.75 mm (0.110-inch). Finished lines shall be within 6 mm (0.25 inch) of the width specified in the plans.

The Contractor shall place the thermoplastic markings with an adequate drop on glass beads according to Article 1095, uniformly applied to assure adequate nighttime reflectivity. It shall be the Contractor's responsibility to use a compatible combination of thermoplastic material and beads to preclude the surface beads from sinking deeply into the thermoplastic.

The thickness of the markings will be measured above the pavement surface at random points as selected by the Engineer, to determine conformance.

- (a) If the measurements show less than 2.50 mm (0.100 inch), the Engineer will "chip" the edges of the markings at random points and measure the thickness of the chips to determine if the overall thickness of the markings is at least 2.50 mm (0.100 inch). When either the overall thickness or the thickness above the pavement surface is substantially in conformance with the thickness requirements, payment will be made at 100 percent of the contract unit prices involved.
- (b) If the thickness at a given location is less than 2.50 mm (0.100 inch), additional measurements will be taken on each side of the location by the Engineer to determine the extent of the deficient portion of the marking. If the average thickness of the deficient portion is less than 2.50 mm (0.100).

inch) but more than 1.50 mm (0.060 inch), an adjusted unit price of 50 percent of the contract unit price involved will be used in computing payment for the area which is deficient.

- (c) If the measurements show the average thickness to be less than 1.50 mm (0.060 inch), the Contractor shall grind away the surface of the deficient portions of the markings sufficiently to reduce the average thickness to approximately 1.25 mm (0.050 inch) or less. The Contractor shall then apply additional thermoplastic material and beads to bring the thickness of the markings to at least 2.50 mm (0.100 inch) and the reflectivity to the minimum required values.
- **780.06 Paint.** Prior to application of the paint pavement marking, the Contractor shall make certain the pavement surface is dry and free of dirt or grease and, if necessary, clean the surface to the satisfaction of the Engineer.

Paint shall not be applied at air temperatures below 10 °C (50 °F.), unless approved by the Engineer.

The paint shall be applied at a minimum thickness of  $406 \,\mu m$  (16 mils) and beads shall be applied to all painted surfaces at the minimum rate of 720 g for each L (6.0 lbs. for each gal.) of paint used.

Unless directed by the Engineer, lines shall not be laid directly over a tar or asphalt painted lines.

**780.07 Preformed Plastic.** The markings shall be capable of being applied on either newly paved asphalt concrete surfaces by being inlaid into the surface, or on new and existing portland cement concrete and asphalt concrete surfaces, by means of a pressure-sensitive, precoated adhesive, or a liquid contact cement which shall be applied at the time of installation.

The pavement shall be cleaned as recommended by the manufacturer.

Cleaning operations shall not begin until a minimum of 30 days after the placement of new concrete.

The cleaning operation shall remove all visible evidence of curing compound on the peaks and valleys of textured concrete surfaces, remove all loose and flaking material and round any sharp edges and irregularities.

When recommended by the manufacturer a primer sealer shall be applied on all pavement surfaces where new preformed plastic pavement marking material is to be applied. The primer sealer shall be recommended by the manufacturer of the preformed plastic pavement material and shall be compatible with the material being used. The primer sealer shall be applied in sufficient quantities to entirely cover the pavement surface where the plastic material is to be placed. The Contractor shall not install the preformed plastic pavement markings until the primer sealer dries according to the manufacturer's recommendations.

The markings placed on the pavement shall be rolled and compacted onto the pavement with a roller or tamper cart approved by the manufacturer. This roller shall be loaded with or weigh at least 90 kg (200 lbs.). The Contractor shall tamp and roll the material sufficiently to prevent easy removal or peeling. Rolling of letters, symbols and materials 300 mm (12 inch) or wider shall not be with a vehicle, but with an

approved roller. Care shall be taken to cut the material in and around pavement joints or cracks and roll the material into the cracks of joints.

(a) Type A. On freshly placed asphalt concrete, the inlaid markings shall be applied before final compaction and when the pavement temperature has cooled to approximately 65 °C (150 °F.) and when, in the opinion of the Engineer, the pavement is acceptable for vehicular traffic.

The markings shall be applied at a minimum thickness of 1.5 mm (0.06 inch).

The markings shall be placed on the pavement by means of a mechanical applicator or by a hand method and embedded into the pavement surface with a compaction roller with minimum water on the roller. Vibrators shall not be used.

The initial rolling of the markings shall be in the same direction as the application to minimize buckling in front of the roller. The roller shall not be allowed to turn on the markings.

The markings shall be embedded to a depth of approximately 1.0 mm (0.04 inch) and to the satisfaction of the Engineer.

- (b) Type B or C. The material shall be applied only when the air temperature is 15 °C (60 °F.) or above and rising and the pavement temperature is 21 °C (70 °F.) or greater and in no case later than October 15 for non-inlaid applications. When the preformed plastic markings cannot be placed according to these specifications and the road is to be opened to traffic after October 15 with no adequate pavement markings in place, the Contractor shall at the direction of the Engineer, place preformed tape for lane lines. All other pavement markings shall be placed according to Article 703.05. The Contractor shall then place the preformed pavement markings on or as soon after April 15 as the requirements of these specifications can be met or at such time as may be agreed upon by the Engineer. Payments for placing these temporary pavement markings will be according to Article 703.07.
- **780.08 Preformed Thermoplastic.** The pavement markings shall be capable of being applied on either asphalt surfaces or portland cement concrete surfaces by using a propane blowtorch.

When recommended by the manufacturer of the preformed pavement marking material, a primer sealer shall be applied on portland cement concrete surfaces prior to application of the preformed thermoplastic pavement marking material. The primer sealer material shall be applied in sufficient quantities to entirely cover the pavement surface where the pavement marking material is to be placed.

The pavement temperature and the ambient air temperature shall be at or above 0  $^{\circ}$ C (32  $^{\circ}$ F.) at the time of installation of the pavement markings.

**780.09 Epoxy.** The pavement shall be cleaned by a method approved by the Engineer to remove all dirt, grease, glaze, or any other material that would reduce the adhesion of the markings with minimum or no damage to the pavement surface. New pcc pavements shall be blast-cleaned to remove all latents.

Markings shall be applied to the cleaned surface on the same calendar day. If this cannot be accomplished, the surface area shall be recleaned prior to applying the markings. No markings shall be placed until the Engineer approves the cleaning.

Widths, lengths, and shapes of the cleaned surface shall be of sufficient size to include the full area of the specified pavement marking to be placed or removed.

The cleaning operation shall be a continuous moving process with minimum interruption to any traffic.

The material shall be applied to the cleaned road surface at  $0.51 \pm 0.01$  mm (20 mils  $\pm$  1 mil) in thickness, before the glass beads are applied. Glass beads shall be uniformly applied by means of a double drop pressurized bead applicator system. The system shall apply both the first drop glass beads and the second drop glass beads at a rate of 1.2 kg per L (10 lbs. per gal.). Epoxy pavement marking shall be applied only when the air and surface temperature are a minimum of 2 °C (35 °F.) and rising. Where epoxy markings cannot be placed according to these specifications and the road is open to traffic with no adequate pavement markings in place, the Contractor shall place temporary pavement markings according to Section 703.05.

Lane lines shall be applied within 4 calendar days after removal of any existing lane lines.

The Contractor shall provide the Engineer an accurate temperature measuring device(s) which shall be capable of measuring the pavement temperature prior to the application of the material, the material temperature at the gun tip and the material temperature prior to mixing.

**780.10 Inspection.** The epoxy, thermoplastic, preformed thermoplastic, and preformed plastic Type A, B, or C, pavement markings will be inspected following installation, but no later than October 15 for preformed plastic markings, November 1 for thermoplastic and preformed thermoplastic markings, and December 15 for epoxy markings. In addition, they will be inspected following a winter performance period that extends 180 days from November 1.

Within 15 calendar days after the end of the winter performance period, a final performance inspection will be made. Final acceptance requirements are as follows:

- (a) Lane lines: 90 percent by area of each individual dashed line segment.
- (b) Crosswalks, stop lines, arrows, and words: 90 percent by area of each individual line, symbol, or letter.
- (c) Center lines, edge lines, gore markings, and channelizing lines: 90 percent by area measured over any 3 m (10 ft.) length of any individual line regardless of width.
- (d) Entire project: measured in its entirety according to (a), (b), and (c) above, the entire project shall be 95 percent intact.

Upon completion of the final performance inspection, or after satisfactory completion of any necessary correction, the Engineer will notify the Contractor, in writing, of the date of such final performance inspection and release him/her from further performance responsibility.

If this inspection discloses any work, in whole or in part, which does not meet the

inspection requirements, the Contractor shall, within 30 calendar days, completely repair or replace such work to the satisfaction of the Engineer.

This performance inspection and performance acceptance of the epoxy, thermoplastic, preformed thermoplastic, and preformed plastic Type A, B, C pavement markings shall not delay acceptance of the entire project and final payment due if the Contractor requires and receives from the subcontractor a third party "performance" bond naming the Department as obligee in the full amount of all pavement marking quantities listed in the contract, multiplied by the contract unit price. This bond shall be according to Article 103.04. The bond shall be executed prior to acceptance and final payment of the nonthermoplastic items and shall be in full force and effect until final performance inspection and performance acceptance of the thermoplastic, preformed thermoplastic, and preformed plastic pavement markings. Execution of the third party bond shall be the option of the prime Contractor. A third party bond is not required where the prime Contractor performs the thermoplastic work and the retainage is sufficient to cover the cost of such work.

#### 780.11 Method of Measurement.

- (a) Contract Quantities. The requirements for the use of contract quantities shall be according to Article 202.07(a).
- (b) Measured Quantities. The lines will be measured for payment in meters (feet) of thermoplastic, preformed thermoplastic, preformed plastic, epoxy, and paint pavement marking lines applied and accepted, measured in place. Double yellow lines will be measured as two separate lines. Words and symbols shall conform to the sizes and dimensions specified in the Illinois Manual on Uniform Traffic Control Devices and Standard 780001 and will be measured based on the total areas indicated in Table 1 or as specified in the plans.
- **780.12 Basis of Payment.** This work will be paid for at the contract unit prices per meter (foot) of applied line width, as specified, for THERMOPLASTIC PAVEMENT MARKING LINE, PAINT PAVEMENT MARKING LINE, EPOXY PAVEMENT MARKING LINE, PREFORMED PLASTIC PAVEMENT MARKING LINE TYPE A, B, C, PREFORMED THERMOPLASTIC PAVEMENT MARKING LINE and/or per square meter (square foot) for THERMOPLASTIC PAVEMENT MARKING LETTERS AND SYMBOLS, PAINT PAVEMENT MARKING LETTERS AND SYMBOLS, EPOXY PAVEMENT MARKING LETTERS AND SYMBOLS, PREFORMED PLASTIC PAVEMENT MARKING TYPE A, B, OR C LETTERS AND SYMBOLS, PREFORMED THERMOPLASTIC PAVEMENT MARKING LETTERS AND SYMBOLS. The Contractor may use preformed plastic pavement marking or thermoplastic pavement marking, meeting the applicable requirements of Articles 1095 and 780, for diagonal lines, stop bars, and letters and symbols in lieu of epoxy at no extra compensation.

When the Contractor has the option of applying Permanent Pavement Marking it shall be Thermoplastic, Preformed Plastic (Type A, B, or C), Epoxy, or Preformed Thermoplastic Pavement Markings. It will be paid for a the contract unit price per meter (foot) of applied line for PERMANENT PAVEMENT MARKING - LINE 100 (4), 125 (5), 150 (6), 200 (8), 300 (12), 400 (16), or 600 (24) mm (inches) and per square meter (square foot) for PERMANENT PAVEMENT MARKING - LETTERS AND SYMBOLS.

\*TABLE 1

## LETTERS m<sup>2</sup>(sq. ft.)

Size	Α	В	С	D	Е	F	G	Н	I
1.8 m	0.28	0.37	0.25	0.31	0.31	0.24	0.31	0.31	0.14
(6.ft.)	(3.1)	(4.0)	(2.7)	(3.4)	(3.3)	(2.6)	(3.3)	(3.4)	(1.5)
2.4 m	0.51	0.66	0.45	0.57	0.55	0.44	0.54	0.56	0.24 (2.6)
(8 ft.)	(5.5)	(7.1)	(4.8)	(6.1)	(5.9)	(4.7)	(5.8)	(6.0)	



Size	J	K	L	М	N	0	Р	Q	R
1.8 m	0.2	0.28	0.20	0.39	0.37	0.31	0.28	0.33	0.33
(6.ft.)	(3.1)	(4.0)	(2.7)	(3.4)	(3.3)	(2.6)	(3.3)	(3.4)	(1.5)
2.4 m	0.51	0.66	0.45	0.57	0.55	0.44	0.54	0.56	0.24 (2.6)
(8 ft.)	(5.5)	(7.1)	(4.8)	(6.1)	(5.9)	(4.7)	(5.8)	(6.0)	

Size	S	Т	U	V	W	Х	Υ	Z
1.8 m	0.30	0.20	0.30	0.25	0.39	0.25	0.20	0.26
(6.ft.)	(3.2)	(2.2)	(3.2)	(2.7)	(4.2)	(2.7)	(2.2)	(2.9)
2.4 m	0.53	0.35		0.45	0.68	0.45	0.36	0.47
(8 ft.)	(5.7)	(3.8)		(4.8)	(7.3)	(4.8)	(3.9)	(5.1)

### NUMBERS m<sup>2</sup>(sq. ft.)

Size	1	2	3	4	5
1.8 m	0.14	0.31	0.31	0.26	0.33
(6.ft.)	(1.5)	(3.3)	(3.3)	(2.9)	(3.5)
2.4 m	0.24	0.54	0.54	0.47	0.57
(8 ft.)	(2.6)	(5.8)	(5.8)	(5.1)	(6.1)

Size	6	7	8	9	0
1.8 m	0.33	0.20	0.35	0.33	0.31
(6.ft.)	(3.5)	(2.2)	(3.8)	(3.5)	(3.4)
2.4 m	0.58	0.35	0.62	0.58	0.56
(8 ft.)	(6.2)	(3.8)	(6.7)	(6.2)	(6.0)

SYMBOLS m<sup>2</sup>(sq. ft.)

	Large Size	Small Size
Through Arrow	1.07 (11.5)	0.60 (6.5)
Left or Right Arrow	1.47 (15.6)	0.60 (6.5)
Combination Left (Right) and Through Arrow	2.42 (26.0)	1.37 (14.7)
Railroad "R" 1.8 m (6 ft.)	0.33 (3.6)	

	Railroad "X" 6.1 m (20 ft.)	5.02 (54.0)	
	Handicapped Symbol	0.43 (4.6)	1

<sup>\*</sup>Table applies to all types of pavement marking materials.



### SECTION 781. RAISED REFLECTIVE PAVEMENT MARKERS

**781.01 Description.** This work shall consist of placing permanent and/or temporary raised reflective pavement markers or replacing the reflective element in a raised reflective pavement marker.

**781.02 Materials.** Materials shall be according to the following Articles of Section 1000 - Materials:

ltem Ar	ticle/Section
(a) Raised Reflective Pavement Markers	1096.01
(b) Temporary Raised Reflective Pavement Markers	1096.02

#### **CONSTRUCTION REQUIREMENTS**

**781.03 General.** The reflector may be attached to the casting prior to or after the placement of the markers. The depression in the web shall be clean and dry. The reflector shall be laminated to an elastomeric pad and adhesively attached to the casting. The protective paper or plastic film covering the adhesive pad shall be removed immediately prior to placing the reflector on the casting. Once the film covering is removed, extreme care shall be taken to avoid contamination of the exposed pad surface. An adhesive meeting the marker manufacturer's specifications shall be used. The adhesive shall be placed either on the reflector or on the web in sufficient quantity so as to ensure complete coverage of the contact area with no voids present and with a slight excess after the reflector is pressed in place.

(a) Permanent. It shall be the Contractor's responsibility to determine the location of any traffic control devices installed in the the pavement before beginning work, and shall conduct work to avoid damage to these devices. Any damage to these devices caused by the Contractor's operation shall be repaired at the Contractor's expense and to the satisfaction of the Engineer.

The pavement shall be cut to match the bottom contour of the marker using a concrete saw fitted with 450 and 250 mm (18 and 10 inch) diameter blades. Diamond blades shall be used on pcc pavement. The cut shall be clean and completely dry prior to pouring the epoxy. After the cut is cleaned, the configuration shall be checked using a pavement marker. The marker shall fit easily within the cut with the leveling tabs resting on the pavement. If any force is required to place or remove the marker or if the leveling tabs do not rest on the pavement surface, the cut shall be enlarged as necessary. Installations on crowned pavements, superelevations, or ramps shall be cut deeper than those on level pavements if necessary to get proper marker fit. The epoxy shall be poured into the cut to within 9 mm (3/8 inch) of the pavement surface.



The marker shall then be placed into the epoxy-filled cut. The leveling tabs shall rest on the pavement surface and the marker tips shall be slightly below the pavement surface when properly installed. There shall be no epoxy on the reflective lens. The epoxy, when properly mixed, shall be hard cured in 30-45 minutes. If after one hour, a screwdriver or other appointed instrument can be pushed into the epoxy, the marker and the uncured epoxy shall be removed, the marker shall be cleaned and the unit reinstalled.

The pavement surface temperature and the ambient air temperature shall be at or above 10 °C (50 °F.) at the time of installation of the marker for the epoxy adhesive to properly cure.

Unless directed by the Engineer, raised reflective pavement markers shall not be laid directly over a longitudinal crack or joint. The edge of a raised reflective pavement marker shall be offset a minimum distance of 50 mm (2 inch) from the edge of pavement, from a longitudinal crack or joint and from a solid lane line, toward traffic. Raised reflective pavement markers shall be centered in the gap between dashed line segments and the finished line of the markers shall be straight. The lateral deviation on any 3 m (10 ft.) line shall not exceed 25 mm (1 inch). Raised reflective pavement markers through tangents of reverse curves which are less than 150 m (500 ft.) in length shall be installed at the lesser of the two curve spacings.

The reflectors may be attached to the castings either prior to or after the placement of the markers. The depression in the web shall be clean and dry. The reflector shall be placed on the casting with sufficient pressure to firmly seat it in place, minimum load of 45 kg (100 lbs.). Adhesive material shall not be permitted on the reflective surface of the prismatic reflector.

(b) Temporary. The pavement surface which the marker shall be bonded to, shall be free of dirt, curing compound, grease, oil, moisture, or any other material which would adversely affect the bond of the adhesive. The markers shall be placed firmly on the pavement and pressed into place by slowly passing over them with a truck wheel. The pass shall not displace the markers. In lieu of an adhesive pad, an adhesive meeting the marker manufacturer's specifications may be used. The adhesive shall be placed either on the reflector or on the web in sufficient quantity so as to ensure complete coverage of the contact area with no voids present and with a slight excess after the reflector is pressed in place.

All markers shall be monodirectional. Markers placed to the left of traffic shall be amber and markers placed to the right of traffic shall be crystal.

(c) Replacement. All remaining portions of the existing reflector, and all traces of adhesive, rust, dirt, etc., shall be removed from the marker reflector area by sandblasting or other methods approved by the Engineer.

The Contractor shall be responsible for verifying the model numbers of castings as shown on the plans and shall be responsible for installing the proper replacement reflector in each casting.

The Contractor shall make certain the casting surface is dry and free of dirt and rust prior to placing the reflector on the casting.

The reflector shall be placed on the casting with sufficient pressure to firmly seat it in place, minimum load of 45 kg (100 lbs.). Adhesive material shall not be permitted on the reflective surface of the prismatic reflector. The pavement surface temperature and the ambient air temperature shall be at or above 10 °C (50 °F.) at the time of application of the prismatic reflector.

**781.04** Inspection of Raised Reflective Pavement Markers. The permanent raised reflective pavement marker and/or replacement reflector will be inspected following installation, but no later than November 30. In addition, they will be inspected following a winter performance period that will extend 180 days from November 30.

Within 15 calendar days after the end of the winter performance period, a final performance inspection will be made. If this inspection discloses any work which is not visibly intact and serviceable, the Contractor shall, within 30 calendar days, completely repair or replace such work to the satisfaction of the Engineer.

Measured in its entirety, project shall be 97 percent intact.

Upon completion of the final performance inspection or after satisfactory completion of any necessary corrections, the Engineer shall notify the Contractor in writing of the date of such final performance inspection and release him from further performance responsibility.

This delay in performance inspection and performance acceptance of the raised reflective pavement markers shall not delay acceptance of the entire project and final payment due if the Contractor requires and receives from the subcontractor a third party "performance" bond naming the Department as obligee in the full amount of all raised reflective pavement marker quantities listed in the contract, multiplied by the contract unit price. The bond shall be executed prior to acceptance and final pavement of the nonraised reflective pavement marker items and shall be in full force and effect until final performance inspection and performance acceptance of the raised reflective pavement markers. Execution of the third party bond shall be the

option of the prime Contractor. A third party bond will not be required when the prime Contractor performs the raised reflective pavement marker work and the retainage is sufficient to cover the cost of such work.

**781.05 Basis of Payment.** This work will be paid for at the contract unit price each for RAISED REFLECTIVE PAVEMENT MARKER, TEMPORARY RAISED REFLECTIVE PAVEMENT MARKER, and REPLACEMENT REFLECTOR.

#### **SECTION 782. PRISMATIC REFLECTORS**

- **782.01 Description.** This work shall consist of furnishing and installing prismatic reflectors on concrete barriers, bridge parapet walls, and mountable or barrier curbs.
- **782.02 Materials.** Materials shall be according to Articles of Section 1000 Materials:

		Item Article	/Section
	(a)	Prismatic Barrier Reflectors	1095
	(b)	Prismatic Barrier Reflectors	1095

**782.03 General.** The surface of the barrier, bridge parapet wall or curb to which the reflector shall be applied shall be free of dirt, curing compound, moisture, paint, or any other material which would adversely affect the bond of the adhesive. Cleaning of the surface shall be to the satisfaction of the Engineer.

An adhesive meeting the reflector manufacturer's specifications shall be placed either on the surface or the bottom of the reflector in sufficient quantity to ensure complete coverage of the contact area with no voids present and with a slight excess after the reflector is pressed firmly in place.

**782.04** Basis of Payment. This work will be paid for at the contract unit price each for MONODIRECTIONAL or BIDIRECTIONAL, PRISMATIC BARRIER REFLECTOR, and PRISMATIC CURB REFLECTOR. Where bidirectional units (two reflective surfaces) are specified, the Contractor may, at no extra cost to the Department, furnish two separate monodirectional units (single reflective surface) and mount them back to back.

#### SECTION 783. PAVEMENT MARKING AND MARKER REMOVAL

- **783.01 Description.** This work shall consist of removing existing pavement markings and raised reflective pavement markers.
- **783.02 Equipment.** Equipment shall be according to the requirements of the following Articles of Section 1100 Equipment.

	Item	Article/Section
(a)	Portable Shotblaster	1101.13
(b)	Grinders (Note 1)	

Note 1. Grinding equipment shall be approved by the Engineer.

#### CONSTRUCTION REQUIREMENTS



**783.03** Removal of Conflicting Markings. Existing pavement markings that conflict with revised traffic patterns shall be removed as directed by the Engineer and shall be scheduled immediately to facilitate a change in lane assignments which requires removal of conflicting markings. If darkness or inclement weather prohibits the removal operations, such operations shall be resumed the next morning or when weather permits. In the event of removal equipment failure, such equipment shall be repaired, replaced, or leased so removal operations can be resumed within 24 hours.

The existing pavement markings shall be removed from the pavement by a method that does not materially damage the surface or texture of the pavement or surfacing. Very small particles of tightly adhering existing markings may remain in place, if in the opinion of the Engineer, complete removal of the small particles will result in pavement surface damage. Any damage to the pavement or surfacing caused by pavement marking removal shall be repaired by the Contractor at his/her own expense by methods acceptable to the Engineer. Where blast cleaning is used for the removal of pavement markings, care should be taken to protect all vehicular traffic from damage. When permanent raised reflective pavement markers are present and conflict with the revised traffic patterns, only the reflectors shall be removed.

The shape of the obliterated strip shall be disguised so the pattern of the removed marking is not retained. Where mechanical means of marking removal have been employed, flat paint of a color matching the pavement surface or an asphaltic seal coat may be used if necessary as a means of covering contrasting pavement texture. The cost of the flat paint shall be included in the cost of pavement marking removal. The use of flat paint to cover conflicting pavement markings will not be allowed.

**783.04 Cleaning.** The roadway surface shall be cleaned of debris, blast sand or any other deleterious material by the use of jets of compressed air or water. When the shotblast method is used, the Contractor will be responsible for collecting and recycling the steel shot.

Over cleaning to the extent of possible damage to the roadway surface shall be held to a minimum.

#### 783.05 Method of Measurement.

- (a) Contract Quantities. The requirement for use of contract quantities shall be according to Article 202.07(a).
- (b) Measured Quantities. The existing pavement marking removal will be measured in square meters (square feet). For payment purposes, all existing lines, letters and symbols shall be measured in square meters (square feet).
- **783.06** Basis of Payment. This work will be paid for at the contract unit price each for RAISED REFLECTIVE PAVEMENT MARKER REMOVAL, or at the contract unit price per square meter (square foot) for PAVEMENT MARKING REMOVAL.

### **SECTION 800. ELECTRICAL REQUIREMENTS**

### **SECTION 801. GENERAL ELECTRICAL REQUIREMENTS**

**801.01 Definition.** For electrical work the following additional definitions shall apply:

<u>Equipment.</u> Materials, fittings, devices, appliances, fixtures, apparatus, and the like used as part of, or in connecting with, electrical installation.

**801.02 Standards of Installation.** Materials and equipment shall be installed according to the manufacturer's recommendations and according to The National Electrical Code and where applicable, AASHTO's Standard Specifications For Structural Supports For Highway Signs, Luminaires and Traffic Signals.

# 801.03 Protection and Safety.

- (a) Safety. Electrical systems shall not be left in an exposed or otherwise hazardous condition. All electrical boxes, cabinets, pole handholes, etc. which contain wiring, either energized or nonenergized, shall be closed or shall have covers in place and be locked when possible, during nonworking hours.
- (b) Protection. Electrical raceway or duct openings shall be capped or otherwise sealed from the entrance of water and dirt. Wiring shall be protected from mechanical injury.
- **801.04 Marking Proposed Locations for Highway Lighting System.** The Contractor shall mark or stake the proposed locations of all poles, cabinets, junction boxes, pull boxes, handholes, cable routes, pavement crossings, and other items pertinent to the work. A proposed location inspection by the Engineer shall be requested prior to any excavation, construction, or installation work after all proposed installation locations are marked. Any work installed without location approval is subject to corrective action at the Contractor's expense.

# 801.05 Inspection of Electrical Systems.

- (a) Highway Lighting Wiring. Before any splice, tap, or ground connection is permanently trained in handholes, junction boxes, light poles, or other enclosures, the Contractor shall notify and make available such wiring for the Engineer's inspection.
- (b) Traffic Signal Equipment. The Contractor shall prepare the traffic signal equipment at a suitable location, meeting the approval of the Engineer, so it may be readily inspected and tested by the Engineer. Prior to testing, all components shall be identified as to the vehicle movements. The inspector will tag the equipment that has been inspected and it may then be delivered to the job site. No equipment will be inspected unless a written request for inspection is delivered to the Engineer at least a week in advance. Equipment not complying with this requirement that has been installed on the job will be done at the Contractor's own risk and may be subject to removal and replacement at the Contractor's expense.

# 801.06 Damage to Electrical System.

(a) Highway Lighting. Should damage occur to any existing electrical systems through the Contractor's operations, the Engineer will designate the repairs as emergency or non-emergency in nature.

Emergency repairs will be made by the Department or its agent. Non-emergency repairs shall be performed by the Contractor within 6 working days following discovery or notification, to the satisfaction of the Engineer. All repairs shall be performed in an expeditious manner to assure all electrical systems are operational as soon as possible. The cost of those repairs shall be the responsibility of the Contractor and no additional compensation will be allowed.

Temporary aerial multi-conductor cable, with grounded messenger cable, will be permitted if it does not interfere with traffic or other operations and if the Engineer determines it does not require unacceptable modification to existing equipment.

The outage will be considered an emergency when 3 or more lights on a circuit or 3 successive lights are not operational. Knocked down equipment which results in a danger to the motoring public will be considered an emergency repair.

(b) Traffic Signal. Any damage to the signal whether existing, new or temporary from any cause shall be repaired or replaced by the Contractor at his/her own expense. The Contractor shall install "STOP"(R1-1-3636) signs on the approaches to the intersection as a temporary means of regulating traffic during the time of repair when required by the Engineer.

### 801.07 Contract Guarantee.

(a) Highway Lighting. The Contractor shall guarantee all electrical equipment, apparatus, materials, and workmanship provided under the contract for a period of 6 months after the date of final inspection according to Article 801.17.

All instruction sheets required to be furnished by the manufacturer for materials and supplies and for operations shall be delivered to the Engineer prior to acceptance of the project, with the following warranties and quarantees:

- (1) The manufacturer's standard written warranty for each piece of electrical equipment or apparatus furnished under the contract.
- (2) The Contractor's written guarantee that, for a period of 6 months after the date of final inspection of the project, all necessary repairs to or replacement of said warranted equipment or apparatus shall be made by the Contractor at no cost to the Department.
- (3) The Contractor's written guarantee for satisfactory operation of all electrical systems furnished and constructed under the contract for a period of 6 months after final inspection of the project.
- (b) Traffic Signals. The Contractor shall obtain from the manufacturers,

warranties for all electronic and mechanical equipment which performs logic, timing, or communication functions. These warranties shall be transferred to the Department or other maintaining agencies upon the completion and acceptance of the project. The warranties shall cover a minimum of 6 months from the date the equipment is placed in operation. The manufacturer shall warrant the equipment and all parts thereof against any defects of design, workmanship, and materials, and guarantee to promptly repair or replace, free of charge, any item that has become defective for reasons not proven to have been caused by negligence on the part of the user or acts of a third party during the warranty period.

# 801.08 Submittals.

(a) Highway Lighting. At the preconstruction meeting, the Contractor shall submit a written listing of manufacturers for all major electrical equipment items. The list of manufacturers shall be binding except by written request from the Contractor and approval by the Engineer. The request shall include acceptable reasons and documentation for the change.

Major equipment items shall be those items from the following list which are included in the project:

Light Towers
Light Poles
Luminaires
Lighting Controllers
Unit Duct
Cable

Within 30 days after contract execution, the Contractor shall submit, for approval, complete manufacturer's product data (for standard products and components) and detailed shop drawings (for fabricated equipment). Submittals for the equipment and materials for each individual pay item shall be complete in every respect except Materials covered under Article 1085.01 through 1085.10 shall be submitted together and need not be submitted as part of individual pay items submittals. Submittals which include multiple pay items shall have all submittal material for each item or group of items covered by a particular specification, grouped together and the applicable pay item identified. Various submittals shall, when taken together, form a complete coordinated package. A partial submittal will be returned without review unless prior written permission is obtained from the Department.

The Contractor shall have reviewed the submittal material and affixed his/her stamp of approval and signature. In case of Subcontractors submittal, both the Subcontractor and the Contractor shall review, sign, and stamp their approval on the submittal.

Receipt of the submittal information will be construed as the Contractor's assurance that the submittal has been reviewed and attests to the submittals accuracy and conformance to the requirements of the contract. Any deviations to the contract shall be called out in the submittal. Incompleteness, inaccuracy, or lack of coordination will be grounds for

rejection. Equipment or material installed prior to approval by the Engineer, will be subject to removal and replacement at the Contractor's expense.

- (b) Traffic Signals. At the preconstruction meeting, the Contractor shall submit the following items for approval by the Engineer:
  - (1) Five complete copies of the manufacturer's descriptive literatures and technical data for the traffic signal equipment that will be installed on the contract. The descriptive literatures and technical data shall be adequate for determining whether the equipment meets the requirements of the plans and specifications. If the literature contains more than one item, the Contractor shall indicate which item or items will be furnished.
  - (2) Five complete copies of the shop drawings for the mast arm assemblies and poles and the combination mast arm assemblies and poles showing in detail the fabrication thereof and the certified mill analyses of the materials used in the fabrication, anchor bolts, and reinforcing materials.
  - (3) Samples of all conduit and cable, and samples of each type of cable splice that will be used in the work.
  - (4) Unless otherwise approved by the Engineer, all of the above items shall be submitted to the Engineer at the same time. Each item shall be properly identified by route, section and contract numbers.
  - (5) The Engineer will review the literature and furnish written approval or rejection to the Contractor within 15 calendar days after receipt of the literature. If the literature is rejected, the Contractor shall resubmit corrected literature within an additional 15 calendar days. Within 10 calendar days after receipt of written approval of any signal material or equipment, the Contractor shall order such signal material or equipment and shall furnish a copy of such order to the Engineer.
- **801.09 Highway Lighting Certifications.** When certifications are specified and are available prior to equipment manufacture, the certification shall be included in the submittal information. When specified and only available after manufacture, the submittal shall include a statement of intent to furnish certification. All certifications shall be complete with all appropriate test data, dates, and times.
- **801.10 Documentation for Electronic Equipment.** The Contractor shall furnish the Engineer three copies of the following documentary items as furnished by the manufacturers and five copies of the controller cabinet wiring diagrams:

Operation and service manuals. Electronic schematics of circuit boards. Pictorial layout of components of circuit boards. Parts list.

Documentary items shall be furnished for the following equipment:

Signal controllers and master controllers. Inductive loop detectors and light detector amplifiers.

Time base coordinators.
Preemptors.
Transceivers.
Load switches.
Conflict monitors.
Any other equipment that performs a logic, timing or communication function.

**801.11 Traffic Signal Authorized Project Delay.** On traffic signal contracts or contracts having traffic signal work as the controlling item, if requested and approved, the Contractor may delay the start of work for a period of up to 120 consecutive calendar days after the execution of the contract for the delivery of signal material and equipment. This delay must be requested by the Contractor at or prior to the time of the preconstruction meeting.

The Contractor may request an additional delay over and above the 120-day period for nonstandard controllers and the associated equipment and/or nonstandard mast arm and poles. Nonstandard controllers and the associated equipment and/or nonstandard mast arms and poles will be interpreted as those differing significantly from these Specifications or the Highway Standards. A request for additional delay must be accompanied by written documentation from the manufacturer(s) of the nonstandard item(s), stating the anticipated delivery date to the Contractor. A copy of the Contractor's progress schedule showing the anticipated delivery date(s) will not permit completion of the project within the stipulated working days shall accompany the request.

The 120-day delay or such additional delay as may be approved will not be construed to require the Contractor to actually have the material on hand within such period, only that charging of working days will begin at the termination of the approved delay.

**801.12** Highway Lighting Record Drawings. Alterations and additions to the electrical installation depicted on the complete set of Contract Drawings made during the execution of the work shall be neatly and plainly marked in red on full-size set of Record Drawings kept at the Contractor's field office for the project. These drawings shall be updated on a daily basis and shall be available for inspection by the Engineer during the course of the work. The Record Drawings shall include all plans, details, notes, schedules, single line diagrams, etc., applicable to the electrical work and other information useful to locate and maintain the electrical system. As part of the Record Drawings, the Contractor shall inventory all equipment, new or existing, on the project and record information on inventory sheets provided by the Engineer. Upon request, a full-size set of reproducible drawings of the lighting work will be made available to the Contractor for the purpose of compliance with these requirements.

When the work is complete, and 7 days before the request for a final inspection, the full-size set of contract drawings, stamped "RECORD DRAWINGS", shall be submitted to the Engineer for review and approval and shall be stamped with the date and the signature of the Contractor's supervising Engineer or electrician.

**801.13 Traffic Signal Maintenance and Responsibility.** The Contractor shall be responsible for maintaining the traffic signal installation in proper operating condition.

The Contractor shall perform the following maintenance procedures:

- (a) Inspection. Patrol and inspect the signal installation at least once every two weeks for proper alignment of signal heads, lamp outages, and general operation of the traffic signals.
- (b) Correction. Provide immediate corrective action to replace burned-out lamps or damaged sockets with new approved lamps or sockets. At the time of replacement, the reflector and lens shall be cleaned.
- (c) Emergency Calls. Respond to emergency calls including but not limited to dark signals and unprogrammed flashing signals within two hours after notification and provide immediate corrective action. The Contractor shall maintain in stock a sufficient amount of material and equipment to provide temporary and permanent repairs. Any damage to the signal installation from any cause whatsoever shall be repaired or replaced by the Contractor at his own expense.

The Contractor shall install STOP (R1-1-3636) signs on all approaches to the intersection as a temporary means of regulating traffic during the time of repair when required by the Engineer.

- (d) Inspectors. The Contractor shall provide the Engineer the names and telephone numbers of 2 persons who will be available 24 hours a day, 7 days a week, to perform any necessary work on the signal installation.
- (e) The Contractor's signal responsibilities of maintenance, energy charge, and damage repair shall begin and end as follows:
  - (1) New Signal Installation. The signal responsibility shall begin at the start of signal construction and shall end upon issuance of Signal Acceptance Notice by the Engineer.
  - (2) Modify Existing Signals. The signal responsibility shall begin at a date mutually agreed upon between the Contractor, Engineer, and the signal maintaining agency representative but no later than the beginning of construction by the Contractor within 125 m (400 ft.) of the intersection. The signal responsibility shall end upon issuance of Signal Acceptance Notice by the Engineer.
  - (3) Temporary Signals Used During Construction. The signal responsibility shall begin at the start of temporary signal construction and shall end with the removal of the signal as directed by the Engineer.

If, at any time, the Contractor fails to perform any work deemed necessary by the Engineer to keep the traffic signals in proper operating condition, or if the Engineer finds it impossible to contact the designated persons to perform any work, the Department reserves the right to have other electrical contractors perform the needed work. The cost of such work will be deducted from the amount due the Contractor.

# 801.14 Testing.

- (a) Highway Lighting.
  - (1) General. Before final inspection, the electrical equipment, material and

work shall be tested. Tests may be made progressively as parts of the work are completed or may be made when the work is complete. Tests shall be made in the presence of the Engineer. Items which fail to test satisfactorily shall be repaired or replaced. Tests shall include checks of control operation, system voltages, cable insulation and ground resistance and continuity. The forms for recording test readings will be available from the Engineer. The equipment shall have the following minimum ranges and accuracies:

<u>Test</u>	Type of Meter	Accuracy
Voltage Insulation Resistance Current Ground Continuity	Multimeter Megohmmeter Ammeter Low Ohm Meter	+/-2% of reading +/-1% of reading +/-1% of reading +/-1/4% of reading + 1 least significant digit

Meters shall be calibrated within the last year.

- (2) Voltage Measurements. Voltages in the cabinet from phase to phase and phase to neutral at no load and at full load shall be measured and recorded. Voltage readings at the last termination of each circuit shall be measured and recorded.
- (3) Insulation Resistance. Insulation resistance to ground of each circuit at the cabinet, with all loads connected shall be measured and recorded.

On tests of new cable runs, the readings shall exceed 50 megohms for phase and neutral conductors with a connected load over 20 amperes and shall exceed 100 megohms for conductors with a connected load of 20 amperes or less.

On tests of cable runs which include cables which were existing in service prior to this contract, the resistance readings shall be the same or better than the readings recorded at the maintenance transfer at the beginning of the contract. Measurements shall be taken with a megohm meter approved by the Engineer.

- (4) Loads. The current of each circuit, phase main, and neutral shall be measured and recorded. The Engineer may direct reasonable circuit rearrangement. The current readings shall be within 10% of the connected load based on equipment ratings.
- (5) Ground Continuity. Resistance of the system ground as taken from the farthest extension of each circuit run from the controller (i.e. check of equipment ground continuity for each circuit) shall be measured and recorded. Readings shall not exceed 2.0 Ohms regardless of the length of the circuits.
- (6) Resistance of Made Electrodes. Resistance to ground of the service grounding electrode shall be measured and recorded. Measurements shall be made with a ground tester as approved by the Engineer. Resistance to ground shall not exceed 10 Ohms. If a reading exceeds

10 Ohms, additional ground rods shall be added according to N.E.C. Article 250-84. These additional ground rods shall be paid for at the contract unit price for ground rod.

- (b) Traffic Signals.
  - (1) Detector Loop. Before and after permanently securing the loop in the pavement, electronic instruments shall be used to test the resistance, inductance, resistance to ground, and quality factor for each loop and lead-in circuit. The loop and lead-in circuit shall have an inductance between 50 and 700 microhenries. The resistance to ground shall be a minimum of 50 megohms under any conditions of weather or moisture. The quality factor (Q) shall be greater than 5. The Contractor shall provide the necessary instruments and do all the testing in the presence of the Engineer.
  - (2) Fiber Optic Communication System.
    - General. The Contractor shall provide all personnel, equipment, instrumentation and supplies necessary to perform all testing.

The testing shall be performed in an accepted manner and according to the testing equipment manufacturer's recommendations. The test data shall be recorded and submitted to the Engineer.

b. Pre-installation Testing. An Optical Time Domain Reflectrometer (OTDR) shall be used to evaluate the quality and the length of each fiber on cable reels prior to their use on the project. The fiber loss in dB/Km and the length of each strand shall be recorded in the documentation. The attenuation of each fiber shall not exceed 3.5 dB/Km nominal, measured at room temperature at 850 nm, and the attenuation measured shall be compared against that recorded by the manufacturer.

A hard copy of OTDR signature traces for all fibers on each cable reel shall be printed and provided in the documentation to the Engineer.

- c. Post-installation Testing. Each section of the cable shall be tested for the continuity and the attenuation as a minimum. If the attenuation is found not to be within the acceptable nominal values, the Contractor shall use an OTDR to locate points of localized loss caused by bends or kinks, and try to relax these bends or kinks. If this is not successful, the Contractor shall replace the damaged section of the cable with no additional payment. Splices shall not be allowed to repair the damaged section. The Contractor shall provide the Engineer with a written report showing all of the values measured during these tests.
  - Attenuation Test. After installation, the end-to-end attenuation shall be measured for each link by insertion loss testing.

The launch reference cable and the receive reference cable

shall provide for the attachments to the light source and to the power meter respectively. The fiber strand in the launch cable and in the receive cable shall be of the same size and type as the fiber under test.

The launch reference cable shall be connected to the light source and the receive reference cable to the power meter. The two reference cables shall then be connected via a patch panel. A reference power reading (P1) shall then be taken and recorded.

The system link to be tested shall then be inserted between the launch and the receive reference cables using two patch panels. A test power reading (P2) shall then be taken and recorded.

The link attenuation (A) in dB shall be recorded as the difference between the reference power (P1) and the test power (P2).

Link Attenuation, A = P1 - P2

Where P1 = Reference Power P2 = Test Power

This test shall be performed in both directions along the link. The direction of the test shall be recorded in the documentation.

 Transmitter/Receiver Power Level Tests. The output levels at the network hardware transmitters and receivers shall be measured and recorded for system documentation.

The power meter shall be connected to the transmitter side of the equipment with a system jumper. The transmit power level shall then be read and recorded. The transmitter is then reconnected to the cable link and the power meter connected to the receiver side of the equipment. The receiver power level shall then be read and recorded.

3. Continuity Test. Continuity tests shall be used to determine whether a test or system jumper does or does not pass light. A continuity test shall also be used to assure that the fibers have not been crossed over in the jumper and that the transmit fiber goes to the receive fiber.

To perform continuity test, a high-intensity flashlight shall be aimed into the connector at one end, while an observer watches for a flicker of light at the other end.

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d. Documentation. The results of all testing shall be recorded along with the date of the test; the name of the person performing the test; brand name, model number, serial number of the equipment used during the test; and any other pertinent information and data. The complete document set shall be submitted to the Engineer.

#### 801.15 Reserved.

**801.16 Traffic Signal Acceptance.** A signal whether a new installation or an existing modified will be accepted, when the Contractor fulfills the traffic signal requirements of Section 800. Upon successful compliance with the requirements, the issuance of a written Signal Acceptance Notice by the Engineer will constitute the signal acceptance.

For interconnected signals the Signal System Acceptance Notice covering interconnection and system operation will be issued only after the compliance with the requirements on all signals, interconnection, and system operation. The Signal Acceptance Notice may be issued for individual signals under system control that meet all the non-system requirements.

**801.17 Highway Lighting System Final Inspection.** When the work is complete, tested, and fully operational, the Contractor shall schedule a final inspection with the Engineer no less than 7 working days prior to the desired inspection date. The Contractor shall furnish the necessary labor and equipment to make the final inspection.

A written record of the final inspection test readings shall be made during the tests and a copy shall be given to the Engineer. Test results shall be recorded on forms obtained from the Engineer. Spot checks of the progressive testing will be made at the final inspection to verify previous readings.

Any part or parts of the installation that are missing, broken, defective, or not functioning properly during the final inspection shall be noted and shall be adjusted, repaired, or replaced as directed by the Engineer and another inspection shall be made at another date. Only upon satisfaction of all points will the installation be accepted.

Final inspection will not be made until after the delivery of acceptable record drawings, specified certifications, and the required guarantees.

**801.18 Traffic Signal Turn-on or Actuated Operation Inspection.** The Contractor shall request a Turn-on Inspection of a new signal installation and an Actuated Operation Inspection of an existing modified signal after all the signal equipment has been completely installed and fully operable and when the roadway is open to traffic. For the interconnected signals (hardwire, fiber optic, or radio interconnect) all required system hardware and software including but not limited to internal and external modems, telephone drop, master controller, interconnect cable, and Closed Loop software shall be completely installed and fully operable prior to the system inspection request.

The inspection request must be made to the Engineer a minimum of three working days prior to the time of the requested inspection. During the inspection all

the traffic control items will be tested for proper operation according to the contract and to the satisfaction of the Engineer. The Contractor shall be provided with a punchlist indicating the items that failed the inspection and require corrective measures. Upon the Turn-on Inspection, the Engineer may allow the Contractor to activate the signal in continuous operation but this shall not relieve the contractor from correcting the failed items. The Contractor shall notify the Engineer when all the failed items on the punchlist have been corrected and shall request an inspection. A Turn-on or Actuated Operation Inspection shall not be considered successful until each failed item on the punchlist has been corrected by the Contractor to operate according to the contract and to the satisfaction of the Engineer. Only after a successful Turn-on or Actuated Operation Inspection shall the signals be considered ready for the Final inspection and a 30-day on-site acceptance period shall start.

801.19 Traffic Signal Final Inspection (Thirty-day On-site Acceptance). After a successful Turn-on or Actuated Operation Inspection the signals shall enter a 30 calendar days minimum on-site monitoring phase. During this phase the Contractor shall continuously monitor the operation of the traffic signal items including but not limited to controllers, master controller, inductive loop detectors, detector loop, transceivers, modems, conflict monitors and controller cabinets with peripheral equipment. If a Closed Loop system is being installed or being modified, the Contractor shall utilize the system software capabilities to monitor the traffic control items. Failure of any component during the monitoring period, with the exception of expendable items such as light bulbs and fuses, shall be reported to the Engineer and corrective measures shall be taken by the Contractor to the satisfaction of the Engineer. A failed item shall necessitate restarting the 30-day monitoring period for its full 30-day duration beginning at the time when the failed item was corrected by the Contractor to the satisfaction of the Engineer.

At the end of a successful 30-day monitoring period the Contractor shall provide the Engineer with a monitoring log for the items covering the 30-day period. The Contractor shall utilize the system software capabilities to store and generate monitoring logs, if a Closed Loop system is being installed or modified. Upon review of the logs and further equipment performance testing to the satisfaction of the Engineer, he/she will issue a Signal Acceptance Notice/Signal System Acceptance Notice or notify the Contractor in writing of the deficiencies.

# 801.20 Grounding.

- (a) Highway Lighting.
  - Ground rod access well(s) shall be provided at the point of attachment of the grounding electrode conductor to the grounding electrode.
  - (2) One ground rod access well shall be provided at each light tower at a level position adjacent to the light tower foundation.
  - (3) The ground rod shall be buried 300 mm (12 inches) below grade and the access well shall be filled with clay or crushed stone to a point 500 mm (20 inches) below grade as shown on the plans.
- (b) Traffic Signal. The ground rod shall be a copper clad steel solid circular cross section with a nominal diameter of 19 mm (3/4 inch) and provide a minimum cumulative in-soil-contact length of 2.4 m (8 ft.). Resistance to ground shall be according to Article 801.14(a)(6). The ground rod shall be

installed so the acute angle between the rod and the vertical line is not greater than 45 degrees.

If a subsurface condition prohibits the installation of the ground rod to the required length, several ground rods providing a minimum cumulative in-soil-contact length of 2.4 m (8 ft.) shall be bonded together into an array by a No. 6 AWG bare copper wire located 450 mm (18 inches) below finished grade, or the ground rod shall be buried in a trench at a minimum depth of 750 mm (2 1/2 ft.).

A ground clamp capable of accommodating a No. 6 AWG bare copper wire shall be furnished with the rod.

### SECTION 802. LOCATING UNDERGROUND CABLE

**802.01 Description.** This work shall consist of determining the exact locations of all underground electric cable and electric conductors in conduit owned and maintained by the Department which are in possible conflict with construction operations to protect them from damage.

**802.02 General.** Any prints from microfilm or any information shown on the plans for existing underground electrical facilities owned and operated by the Department are intended to show electrical circuitry only, and are not intended to show exact locations of cable or conduits. The Contractor shall be responsible for determining the exact location of any such existing underground electric cable or electric conductors in conduit that are within 1.5 m (5 ft.) of the limits of any excavation or penetration relative to the construction work that could interfere with the underground facilities.

Plans of existing Department owned electrical facilities may be available in the District Office in which the construction is located. Prints of applicable plans will be provided to the Contractor upon request, if available.

The Contractor shall take whatever precautions to protect the electric cable or electric conductors in conduit from damage during location and construction operations. In the event that the wiring is damaged, the Contractor shall replace the entire length of cable or conductors in conduit, in a manner satisfactory to the Engineer, at his/her own expense. Splicing below grade will not be permitted.

In the event the repairs are not made by the Contractor, the Contractor shall reimburse the Department for such repairs within 60 days of receiving written notification of said damage. Otherwise, the cost of such repairs will be deducted from monies due or which will become due the Contractor under the terms of the contract.

If, in the opinion of the Engineer, it is determined prior to any construction that existing electrical wiring at a particular location is such that damage to said wiring is impossible to avoid, the Contractor shall relocate that segment of the existing wiring to avoid his/her operations as directed by the Engineer.

**802.03 Method of Measurement.** This work will be measured for payment in meters (feet) in place for each single buried insulated cable containing multiple conductors or for each single buried conduit containing multiple cables located within an area extending 1.5 m (5 ft.) outside the limits of excavation or penetration in each

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direction. This work will be measured for payment at a specific work location only one time.

**802.04** Basis of Payment. This work will be paid for at the contract unit price per meter (foot) for LOCATING UNDERGROUND CABLE, which price shall include locating each cable, or conduit and protecting it from damage during location and construction operations.

If the Contractor is requested to relocate a segment of cable or conduit at a specific work location to avoid construction operations, this work will be paid for in accordance with Article 109.04. Only that work requested in writing by the Engineer will be paid for.

### WIRING

#### SECTION 810. UNDERGROUND RACEWAYS

**810.01 Description.** This work shall consist of furnishing and installing raceways, fittings and accessories, either laid in trench, pushed in place, bored and pulled, or encased in concrete.

**810.02 Materials.** Materials shall be according to the following Articles of Section 1000 - Materials:

Item Arti	cle/Section
(a) Rigid Metal Conduit	1085.15(a)
(b) Rigid Nonmetallic Conduit	1085.15(b)
(c) Coilable Nonmetallic Conduit	1085.15(c)

**810.03** Installation. All underground conduit shall have a minimum depth of 750 mm (2 1/2 ft.) or 600 mm (2 ft.) below the finished grade as indicated on the plans.

- (a) Rigid Metal Conduit (Steel, Intermediate Metal, Aluminum).
  - (1) General. Installation shall be according to the applicable NEC Articles 345 and 346.

The ends of the conduit shall be cut square and thoroughly reamed before installation. All burrs and rough edges shall be removed.

Bends shall be made with a standard pipe bender. Bends shall be made so the conduit is not injured and the internal diameter of the conduit is not effectively reduced. The radius of the curve shall not be less than shown in Table 346-10 of the NEC or the larger radii specified.

Conduit joints shall be threaded. All joints before assembly and exposed threads after assembly shall be coated with low resistance, conductive, joint compound. Running threads in conduit runs will not be permitted. Conduits shall not be over-threaded. Threading shall be according to NEC Articles 345-8 and 346-7(b). The protective coatings on all threads must be sufficient to prevent corrosion before installation is made. If threads become corroded before installation, the material shall be replaced with new material or the corroded parts thoroughly cleaned and recoated as directed by the Engineer.

Ends of conduits shall be equipped with insulating bushings. Rigid metal conduits terminating in the base of lighting controllers, pedestal bases, transformer bases, and other open enclosures shall be equipped with insulating bushings with ground lugs. The ground lugs shall be used to bond the conduits to the enclosure via a copper grounding conductor.

Conduits terminating at cast or malleable iron boxes shall be terminated in conduit hubs. Hubs shall be integral to the box or installed separately. Non-integral hubs or integral hubs which do not provide a flared, smooth entry shall not be used where conductors are No. 4 or larger, and in these cases two locknuts and an insulating bushing shall be used.

Threaded conduits shall terminate with 2 locknuts and an insulating bushing for sheet metal enclosures above grade.

Conduit connections shall be made tight to assure good grounding continuity.

Conduit below pavement, used as sleeves, shall extend a minimum of 600 mm (2 ft.) beyond the shoulder, curb, and/or guardrail.

The conduit shall be cleaned by rodding and swabbing to remove all dirt and other foreign materials and capped until conductors are installed.

(2) Rigid Metal Conduit Pushed. Pushed conduit shall extend 600 mm (2 ft.) beyond the edge of the paved shoulder surface. The Contractor shall be responsible for damage from work performed on any component of the roadway such as pavement, backslope, driveway, sidewalk, signs, wiring, etc., and shall restore them to their original condition at his/her own expense as directed by the Engineer. Where rock or other obstructions such as broken concrete are encountered at push locations, alternate locations and/or methods may be approved by the Engineer for securing the conduit under the pavement as specified. Costs for moving push locations and restoration shall be considered included in the contract unit prices for the construction items involved and no additional compensation will be allowed.



If auguring is required to facilitate the posts installation, the auguring shall be at the Contractor's expense.

- (b) Rigid Nonmetallic Conduit.
  - (1) General. Installation shall be according to NEC Article 347 Part A.

The conduit shall be cut square. All burrs shall be removed from the inside and outside of the conduit.

(2) Bending. Bending of the conduit shall be made so the conduit will not be damaged and the internal diameter of the conduit will not be effectively reduced. Bends shall be made with standard pipe bending equipment for nonmetallic conduit.

The conduit section shall be heated evenly over the entire length of the bend. The use of torches or other flame-type devices will not be allowed. Sections showing evidence of scorching or discoloration will not be acceptable. The radius of the bend shall not be less than shown in Table 346-10 of the NEC.

(3) Joints. All joints shall be test mated without forcing, then cemented. The socket depth of the fitting shall be marked on the outside of the

### **Underground Raceways**

conduit without scratching or damaging the surface. The conduit shall enter the fitting for the full depth of the socket.

Before applying cement, the surfaces to be joined shall be wiped clean and free of dirt, oil, grease, or moisture. The solvent cement shall be applied according to manufacturer's recommendations.

Immediately after applying the coat of cement to the conduit and fittings, the conduit shall be inserted into the fitting socket until it bottoms at the fitting shoulder. The conduit shall be turned 1/4 turn during insertion to distribute the cement evenly. Excess cement shall be wiped away from the outside of the joint.

Newly assembled joints shall set a minimum of 10 minutes before handling.

(4) Duct Banks. Underground concrete-encased conduit shall be supported on interlocking plastic spacers designed for the purpose, spaced along the length of the run as recommended by the manufacturer. Spacing between raceways within a common duct bank shall be a minimum of 50 mm (2 inches). The interlocking spacers shall be used at a maximum interval of 15 m (5 ft.).

Concrete cover overall shall be a minimum of 75 mm (3 inches) all around the encased run. During concrete placement there shall be no voids, the spacers shall be undisturbed, and the conduit joints shall stay secure and unbroken. Concrete shall be deflected during placement to minimize the possible damage to or movement of the conduits.

Conduit encased in concrete shall have steel reinforcing when installed below roadway or other paved vehicle areas (including shoulder) and the reinforcement shall extend a minimum of 1.5 m (5 ft.) additional from the edge of pavement. Steel reinforcement shall be a minimum of No. 15 (No. 4) bars at corners and otherwise spaced on 300 mm (12-inch) centers, tied with No. 15 (No. 4) bars on 300 mm (12-inch) centers.

All conduit joints and supports shall be inspected and approved by the Engineer before concrete is poured.

- (5) Rigid Conduit Pushed. Conduit shall be pushed according to Article 810.03(a)(2).
- (c) Coilable Nonmetallic Conduit. Coilable Nonmetallic Conduit shall be installed in continuous lengths, without splicing.

Conduit extended to lighting, traffic, and sign structures shall extend 300 mm (12-inches) above the base of the structure.

Bends of conduit shall be made manually so the duct will not be damaged and the internal diameter of the duct will not be effectively reduced. No more than the equivalent of four quarter bends (360 degrees total) shall be made between termination/pull points.

**810.04 Method of Measurement.** This work will be measured for payment in meters (feet) in place. Measurements will be made in straight lines along the centerline of the conduit between ends and changes in direction. Vertical conduit will be measured for payment. The vertical distance required for breakaway devices, barrier wall, concrete pedestals, etc., and the depth of any burial shall be measured. Changes in direction shall assume perfect straight line runs, ignoring actual raceway sweeps. Coilable nonmetallic conduct installed in excess of the limits described will not be measured for payment.

**810.05** Basis of Payment. This work will be paid for at the contract unit price per meter (foot) for CONDUIT IN TRENCH or CONDUIT PUSHED of the type and size specified, or CONDUIT ENCASED, of the type, diameter, and number of raceways wide by the number of raceways high specified.

# **SECTION 811. EXPOSED RACEWAYS**

**811.01 Description.** This work shall consist of furnishing and installing raceways, fittings, and accessories attached to supports.

**811.02 Materials.** Materials shall be according to the following Articles of Section 1000 - Materials:

	Item	Article/Section
(a)	Rigid Metal Conduit	1085.15(a)
(b)	Expansion Fittings for Raceways	

#### 811.03 Installation.

- (a) Rigid Metal Conduit.
  - (1) General. Rigid metal conduit installation shall be according to Article 810.03(a)(1).
  - (2) Supports. Surface-mounted conduits shall be held in place by one-hole clamps and clamp backs. Conduits mounted to steel beams or columns shall be held in place by suitable beam clamps. Clamps, clamp backs, and beam clamps shall be of electro-plated malleable iron.

Raceways suspended from the structure shall be supported by trapeze or other hangers approved by the Engineer. Trapeze hangers shall be hot-dip galvanized steel channels or angle irons with conduits held in place by heavy-duty stainless steel U-bolts, nuts, and lock washers. Trapeze hangers shall be hung using threaded stainless steel rods not less than 10 mm (3/8-inch) diameter and appropriate anchors or by other means approved by the Engineer.

Raceway supports shall be installed according to NEC Article 346-12, with a support within 900 mm (3 ft.) of each cabinet, box, or fitting except the maximum distance between supports shall be as indicated below. The listed exceptions in NEC Article 341-12 shall not apply.

### **Exposed Raceways**

# Conduit Supports

Conduit Diameter		Maximum Distance Between Rigid Metal Conduit Supports
mm	(Inches)	m (ft.)
13-20	(1/2-3/4)	1.5 (5)
25	(1)	1.8 (6)
30-40	(1 1/4-1 1/2)	2.1 (7)
50-65	(2-2 1/2)	2.4 (8)
75	(3) and larger	3 (10)

(b) PVC Coated Rigid Steel Conduit. In addition to the methods described in Article 821.03(a) the following methods shall be observed when installing PVC coated conduit.

PVC coated conduit pipe vise jaw adapters shall be used when the conduit is being clamped to avoid damaging the PVC coating.

PVC coated conduit shall be cut with a roller cutter or by other means approved by the conduit manufacturer.

After any cutting or threading operations are completed, the bare steel shall be touched up with the conduit manufacturer's touch up compound.

(c) Liquid Tight Metal Flexible Conduit. Flexible conduit shall not be used in lieu of the bending conduit. Flexible conduit shall only be used to isolate structure to structure movement or to isolate vibration.

Conduit shall be installed according to NEC Article 351 and shall not exceed 900 mm (36-inches) in length unless approved by the Engineer. Fittings designed for use with liquid-tight flexible conduit shall be used at all connections.

(d) Expansion Fittings. The fittings shall be precisely aligned with the conduit run to assure proper expansion and deflection operation and prevent binding.

For vertical conduit runs, the fitting shall be installed close to the top of the structure to prevent water running across the fitting and entering the conduit.

The fitting's deflection sleeve coupling, and pressure bushing at the barrel of the expansion body, shall be installed flush with the structure ends so that only the connecting expansion nipple crosses the opening between structures.

The fitting shall be supported by points on the conduit immediately adjacent to the fitting. The fitting shall have an external bonding jumper.

- **811.04 Method of Measurement.** Conduit will be measured for payment in meters (feet) in place. Measurements will be made in straight lines along the centerline of the conduit between ends and changes in direction. Vertical conduit will be measured for payment according to Article 820.04. Liquid-tight flexible metal conduit will not be measured for payment, but will be included in the price for conduit attached to structure.
- **811.05 Basis of Payment.** This work will be paid for at the contract unit price per meter (foot) for CONDUIT ATTACHED TO STRUCTURE, of the type and diameter specified.

#### **SECTION 812. RACEWAYS EMBEDDED IN STRUCTURE**

- **812.01 Description.** This work shall consist of furnishing and installing rigid conduit, fittings, and accessories embedded in concrete structures.
- **812.02 Materials.** Materials shall be according to the following Articles of Section 1000 Materials:

	Item	Article/Section
(a)	Rigid Metal Conduit	1085.15(a)
(b)	Rigid Nonmetallic Conduit	1085.15(b)
(c)	Expansion Fittings for Raceways	1085.16

### 812.03 Installation.

(a) General. Conduit embedded in a structure shall be supported on interlocking plastic spacers specifically designed for that purpose and spaced along the length of the run as recommended by the manufacturer. Spacing between raceways within a common structure shall be not less than 50 mm (2 inches). The interlocking spacers shall be used at a maximum interval of 1.5 m (5 ft.). When approved by the Engineer, the conduit may be tied to the reinforcement where the reinforcement precludes the use of the supports.

Concrete cover shall not be less than 75 mm (3 inches) all around the embedded encased run. During concrete placement spacers and conduit joints shall stay secure and unbroken. Concrete shall be deflected during placement to minimize the possible damage to, or movement of, the conduits.

All conduit joints and supports shall be inspected and approved by the Engineer before concrete is poured.

- (b) Rigid Metal Conduit. Conduit installation shall be according to Article 810.03(a)(1).
- (c) Rigid Nonmetallic Conduit. Conduit installation shall be according to Article 810.03(b).
- (d) Expansion Fittings. Expansion fittings shall be installed according to Article 811.03(d).

For outdoor roadway structure expansion joints, the barrel of the fitting providing expansion shall be fully embedded in one side of the expansion joint. The other side shall have a cavity opening approximately 75 mm (3 inches) larger in diameter than the deflection sleeve and 1/2 the length of the deflection sleeve deep. The deflection fitting shall be centered in the cavity opening and placed in concrete only up to its center.

For rigid metal conduit the fitting shall have an external bonding jumper for the expansion part of the fitting and an internal bonding jumper for the deflection sleeve that spans the entire deflection sleeve fitting. No bonding jumper is required for rigid nonmetallic conduit.

**812.04 Method of Measurement.** Conduit will be measured for payment in meters (feet) in place. Measurements will be made in a straight line along the centerline of the conduit between ends and changes in direction. Vertical conduit will be measured for payment according to Article 810.04.

**812.05** Basis of Payment. This work will be paid for at the contract unit price per meter (foot) for CONDUIT EMBEDDED IN STRUCTURE, of the type and diameter specified.



# **SECTION 813. JUNCTION AND PULL BOXES**

**813.01 Description.** This work shall consist of furnishing and installing a junction or pull box.

**813.02 Materials.** Materials shall be according to the following Articles of Section 1000 - Materials:

	Item Articl	e/Section
(a)	Stainless Steel Junction Box	1085.17
(b)	Composite Concrete Junction Box	1085.18
(c)	Cast Iron Junction Box	1085.20
(d)	Concrete Junction Box	1085.19
	Reinforced Plastic Mortar Junction Box	

**813.03 Installation.** Exposed junction boxes on structures shall be installed on 13 mm (1/2-inch) long stainless steel or brass spacers with the hinge on top of the box and the cover lying in the vertical plane when closed. The exact orientation shall be as shown on the plans or as directed by the Engineer. Care shall be taken to assure proper orientation of mounting lugs.

The embedded junction box shall be set flush with the adjoining surface and shall be properly supported during concrete placement. If located in shoulder area, the junction box shall be set in concrete with a minimum of 75 mm (3 inches) of concrete on each side and under the bottom of the junction box. Where a junction box is contiguous to sidewalk, preformed joint filler of 13 mm (1/2 inch) thickness shall be placed between the box and the sidewalk. Any backfilling necessary under a pavement, paved shoulder, sidewalk, or within 600 mm (2 ft.) of the pavement edge shall be made with sand or stone screenings. The backfill shall be compacted according to Article 550.07.



**813.04 Basis of Payment.** This work will be paid for at the contract unit price each for JUNCTION BOX, ATTACHED TO STRUCTURE or JUNCTION BOX, EMBEDDED IN STRUCTURE, of the type and size specified which price shall include all items necessary to complete the work. The Contractor may, with the approval of the Engineer, use box sizes larger than indicated, at no additional cost to the Department.



# **SECTION 814. HANDHOLE**

**814.01 Description.** This work shall consist of furnishing the materials and constructing a handhole, a heavy-duty handhole, or a double handhole.

**814.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 - Materials:

### CONSTRUCTION REQUIREMENTS

### 814.03 General.

- (a) Placing Casting. Castings shall be set accurately to the finished elevation so no subsequent adjustment will be necessary. Castings shall be set flush with sidewalk or paved surfaces. When installed in an earth shoulder away from the pavement edge, the top surface of the casting shall be 25 mm (1 inch) above the finished grade.
- (b) Concrete. Concrete shall be cast in place, Class SI, and meet the requirements of Section 502. Where a handhole is contiguous to a sidewalk, preformed joint filler of 13 mm (1/2-inch) thickness shall be placed between the handhole and the sidewalk.
- (c) Backfilling. Any backfilling necessary under a pavement, paved shoulder, sidewalk, or within 600 mm (2 ft.) of the pavement edge shall be made with sand or stone screenings. The backfill shall be compacted according to Article 550.07.
- (d) Cleaning. The handhole shall be thoroughly cleaned of any accumulation of silt, debris, or foreign matter of any kind.



**814.04** Basis of Payment. This work will be measured and paid for at the contract unit price each for HANDHOLE; HEAVY-DUTY HANDHOLE; or DOUBLE HANDHOLE of the size specified.

### **SECTION 815. GULFBOX JUNCTION**

**815.01 Description.** This item shall consist of furnishing and installing a gulfbox junction.

### Gulfbox Junction

**815.02 Materials.** Materials shall be according to the following Articles of Section 1000 - Materials:

Item Ar	ticle/Section
(a) Cast Iron	1085.60
(b) Composite Concrete	1085.60

#### CONSTRUCTION REQUIREMENTS

**815.03 Installation.** The top of the gulfbox shall be set flush with the sidewalk or a paved surface. When installed in earth shoulder away from the pavement edge, the top surface of the gulfbox shall be 25 mm (1 inch) above the finished grade.

When the gulfbox is to be constructed over existing conduit, the conduit shall be cut, 90 degree elbows installed, and the box constructed as detailed in the plans.

- (a) Cast Iron Gulfbox. The installation shall consist of pouring Class SI Concrete around the conduits to a level 190 mm (7 1/2 inch) below the surrounding grade with dimensions as shown in the plans. The conduits shall protrude approximately 15 mm (1/2 inch) above the concrete surface. The casting shall be secured by setting the bottom flange into the concrete surface 12 to 20 mm (1/2 to 3/4 inch) while the concrete is still plastic and then trowel the surface smooth. Any piping slots in the sides shall be suitably plugged.
- (b) Composite Concrete Gulfbox. Installation of the composite concrete box shall consist of placing CA 6 granular material around the conduits to a depth of 300 mm (12 inches) below the surrounding grade. The conduits shall protrude approximately 25 mm (1 inch) above the granular material. The box shall be set on this base and surrounded by an additional CA 6 granular material to the concrete collar shown in the plans.
- **815.04** Basis of Payment. This work will be paid for at the contract unit price each for GULFBOX JUNCTION and of the kind of material when specified.

No additional compensation will be allowed for constructing the gulfbox on existing conduits.

### **SECTION 816. PULLING PEDESTAL**

- **816.01 Description.** The work shall consist of furnishing and installing a pulling pedestal complete.
- **816.02 Materials.** Materials shall be according to the following Articles of Section 1000 Materials:

		Item	Article/S	Section
I	(a)	Pulling Pedestal .		085.22
ĺ	(b)	Concrete (Note 1)		. 1020

Note 1: Class SI concrete shall be used.

### **CONSTRUCTION REQUIREMENTS**

**816.03 General.** Concrete shall be cast in place. The pulling pedestal assembly shall be anchored to the concrete foundation as shown on the plans. The pulling pedestal enclosure shall be mounted atop an enclosure base constructed from the same materials as the cabinet and of the same cross-section as the cabinet. The base extension shall be painted as specified for the cabinet. The foundation shall extend 300 mm (12-inches) above ground.

Except where the pulling pedestal is facing a sidewalk, a poured 100 mm (4 inch) thick concrete pad, not less than 600 mm (48 inches) square, shall be provided in front of the cabinet.

Where a pulling pedestal is contiguous to a sidewalk, preformed joint filler of 13 mm (1/2 inch) thickness shall be placed between the pulling pedestal and the sidewalk.

- **816.04 Grounding.** The pulling pedestal shall be grounded according to Article 1085.04.
- **816.05 Basis of Payment.** This work will be paid for at the contract unit price each for PULLING PEDESTAL, of the size specified. The cost of the ground rod will be included in the cost of the pulling pedestal.

### CABLE

#### SECTION 820. MULTI-CONDUCTOR POWER CABLE

**820.01 Description.** This work shall consist of furnishing and installing multi-conductor direct burial power cable, complete with all splicing, identifications and terminations.

**820.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 - Materials:

#### 820.03 Installation.

(a) General. The multi-conductor cable extended to equipment shall be of a length sufficient for cable splices to be withdrawn a minimum of 450 mm (18 inches) out of pole handholes, pull boxes, or junction boxes.

For preparation of cable termination of splicing, the multi-conductor cable jacket and any underlying tape, shall be removed for a distance of 200 mm (8 inches) from the end of the center conductor. The fillers shall be removed and cut at the end of the jacket. The assembly shall be taped tightly together at the end of the jacket before the conductors are spread apart.

Multi-conductor cable shall not be bent to a radius less than the manufacturer's recommended bending radius, either in permanent placement or during installation.

The cable shall be installed directly from the reels on which the cable was shipped. Dragging or laying cable on the ground will not be permitted. No underground splicing of cable will be permitted.

Immediately after placement, the cable ends shall be sealed to prevent entrance of moisture and contaminates, unless splicing or termination work is performed concurrently.

Splices and terminations shall be according to Article 1085.01 through 1085.08. The multi-conductor cable assembly shall be terminated with a multi-leg heat-shrink boot. The end of the cable shall be wrapped with sealant tape recommended by the boot manufacturer around and between individual insulated conductors, with the boot overall. The boot shall meet military specification Mil 1-81765/1.

- (b) In Trench. The cable shall be installed as indicated on the plans and according to the manufacturer's recommendations. Installation, after inspection by the Engineer, shall be backfilled according to Section 864, except plowing will not be allowed.
- (c) In Raceway. Raceways shall be cleaned and freed of rough spots by reaming or other methods approved by the Engineer. All raceways shall

be swabbed and blown clean with compressed air. Lubricating compounds approved by the cable manufacturer shall be used to facilitate installation of the cable in raceways.

The manufacturer's recommended allowable tension for the conductor or the allowable sidewall load, whichever is smaller, shall be used for maximum pulling tension. Cable pulling apparatus shall have no sharp edges or protrusions which could damage cables or raceways.

**820.04 Method of Measurement.** The cable will be measured for payment in meters (feet) in place. Measurements will be made in straight lines between changes in direction and to the centers of equipment and box access points. Three meters (10 ft.) will be allowed when terminating cable at a controller. One meter (3 ft.) of slack will be allowed at light pole, handholes, pull boxes, junction boxes, and similar locations.

Vertical cable will be measured for payment. The vertical distance required for breakaway devices, barrier walls, concrete pedestals, etc., and the depth of any burial will be measured. Changes in direction shall assume perfect straight line runs, ignoring actual raceway sweeps.

**820.05 Basis of Payment.** This work will be paid for at the contract unit price per meter (foot) for ELECTRIC CABLE ASSEMBLY IN CONDUIT, or TRENCH, 600V of the type, size, and number of conductors indicated.

### **SECTION 821. UNIT DUCT**

- **821.01 Description.** This work shall consist of furnishing and installing preassembled cable in coilable nonmetallic conduit (unit duct), complete with all splicing, identifications, and terminations.
- **821.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 Materials:

	Item	Article/Section
(a)	Unit Duct	1085.29
	Coilable Nonmetal Conduit	
	Conductors	
	Cable Insulation	1085.26

# 821.03 Installation.

(a) General. The unit duct shall be installed according to NEC 343, directly from the reels on which the unit duct was shipped, in continuous spans without splices of any kind between equipment or boxes.

Where unit duct passes through handholes or pull boxes, the polyethylene duct shall be cut open and the continuous, uncut and unspliced conductors exposed and looped within the handhole or pull box. The ends of the polyethylene duct must be sealed with duct sealant and mounted in the handhole to prevent entrance of moisture or contaminants.

Art. 821.03 Unit Duct

When the unit duct is to be pulled, the pulling apparatus shall be attached to the duct and not to the cables. The pulling tension on the duct shall not exceed 2.4 kN (550 lbs.)

Unit duct extended to light poles shall be of a length sufficient for cable splices to be withdrawn a minimum of 450 mm (18 inches) out of pole handholes. The duct of the unit duct assembly shall extend a minimum of 300 mm (12 inches) into pole shafts or transformer bases.

Minimum bending radius for the installed unit duct assembly shall be no smaller than the manufacturer's recommended radius. Bends shall be made so that the duct will not be damaged or kinked and the internal diameter of the duct will not be effectively reduced. There shall not be more than the equivalent of 4 quarter bends between pull points and no bend greater than 90  $^{\circ}.$ 

Immediately after placement, the cable ends shall be sealed to prevent entrance of moisture and contaminates, unless splicing or termination work is performed concurrently.

Splices and terminations shall be according to Articles 1085.01 through 1085.08.

(b) In Trench. The unit duct shall be placed in the bottom of the trench after all loose or protruding stones have been removed or covered with backfill material as directed by the Engineer. The installation, after inspection by the Engineer, shall be backfilled according to Section 864.

The unit duct shall be installed at a minimum depth of 750 mm (30 inches) unless otherwise directed by the Engineer.

Where plowed, the unit duct shall be laid in place and the duct shall not be pulled through the length of the cut behind a bullet-nose mandrel or similar apparatus. Plowing operations shall be non-injurious to the duct.

- (c) In Raceway. Lubricating compounds shall be used where necessary to assure smooth installation.
- **821.04 Method of Measurement.** The unit duct will be measured for payment in meters (feet) in place. Measurements will be made in straight lines between changes in direction and to the centers of equipment and boxes access points. All vertical unit duct and permissible unit duct slack will be measured for payment according to Article 820.04.
- **821.05** Basis of Payment. This work will be paid for at the contract unit price per meter (foot) installed for UNIT DUCT, 600V of the type, size, number and type of conductors and size of duct indicated.

#### **SECTION 822. CABLE IN RACEWAY**

**822.01 Description.** This work shall consist of furnishing and installing electric cables in conduit, complete with all splicing, identifications, and terminations.

**822.02 Materials.** Materials shall be according to the following Articles of Section 1000 - Materials:

	Item	Article/Section
(a)	Conductors	1085.25
(b)	Cable Insulation	1085.26

**822.03 Installation.** Cable shall be installed without damaging the insulation.

Cable lubricant shall be used when pulling cables into conduits. The lubricant shall be non-injurious to conduits, conductors, insulations, or jackets.

Where a number of cables are trained through a box, manhole, or handhole, the cables shall be grouped by circuit where applicable and bundled using appropriate cable ties and supported to minimize pressure or strain on cable insulation.

Wire and cable extended to light poles shall be of a length sufficient for cable splices to be withdrawn a minimum of 450 mm (18 inches) out of pole handholes.

Wire and cable shall not be bent to a radius less than the manufacturer's recommended bending radius, either in permanent placement of during installation. Cable pulling apparatus shall have no sharp edges or protrusions which could damage cables or raceways.

The cable shall be installed directly from the reels on which the cable was shipped. Dragging or laying cable on the ground will not be permitted. The cable shall be installed in continuous spans between termination points.

Immediately after placement, the cable ends shall be sealed to prevent entrance of moisture and contaminates, unless splicing or termination work is performed concurrently.

Splices and terminations, as required, shall be according to Articles 1085.01 through 1085.08.

- **822.04 Method of Measurement.** The cable will be measured for payment in meters (feet) in place. Measurements will be made in straight lines between changes in direction and to the centers of equipment and boxes access points. All vertical cable and permissible cable slack will be measured for payment according to Article 820.04.
- **822.05** Basis of Payment. This work will be paid for at the contract unit price per meter (foot) installed for ELECTRIC CABLE IN CONDUIT, 600 V of the type, size, and number of conductors indicated.

# SECTION 823. AERIAL CABLE FOR LIGHTING

- **823.01 Description.** This work shall consist of furnishing, installing and connection aerial cable complete with all splicing, identifications, and terminations.
- **823.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 Materials:

Item	Article/Section
(a) Conductors	
(b) Aerial Cable Insulation	
(c) Aerial Cable Assembly	

#### 823.03 Installation.

- (a) General. The luminaire connections to the aerial cable shall be made with listed parallel tap insulation piercing connectors. The connector shall be rated for 600 volts and be UL listed under UL Standard 486B.
- (b) Temporary Installation. Upon written request of the Contractor, the Engineer may permit temporary portions of the work to be wired with previously-installed (used) aerial cable of ampacity equivalent to the specified cable and of a type and condition approved by the Engineer. The Contractor shall obtain the inspection and approval of the used cable by the Engineer prior to installation. The cable shall be left in place for the duration of the need for temporary wiring.

In addition to the wiring of temporary equipment indicated, the Contractor shall furnish and install electric feeders and make necessary equipment modifications to connect the existing system(s) to the temporary system(s). Buck-Boost Transformer(s), when indicated on the plans, shall be of the voltage and kVA indicated (or otherwise as applicable for the circuit), dry type, suitable for outdoor installation.

**823.04 Method of Measurement.** The aerial electric cable will be measured in meters (feet) in place and will be taken as the length of the messenger wire. Measurement will be made in a straight line between changes in direction and to the centers of light standards and control cabinets. Sag of the aerial cable or vertical cable will not be measured for payment. When the Engineer requests the used temporary cable be replaced with new, the new cable shall be measured for payment.

Used aerial cable will not be measured for payment but shall be included in the cost of the item.

**823.05** Basis of Payment. This work will be paid for at the contract unit price per meter (foot) for AERIAL CABLE WITH MESSENGER WIRE, of the type, size, and number of conductors specified.

The cost of disconnecting and abandoning in place the existing cables feeding underpass, sign, and ramp lighting and reconnecting to the temporary lighting system shall be included in the contract unit price for this item.

The cost of removing the used cable shall be included in the cost of the new cable. The rewiring to facilitate relocation of the cable due to staging or other construction requirements shall be included in the cost of this item.

### SECTION 824. ELECTRIC CABLE

**824.01 Description.** This work shall consist of furnishing and installing an electric cable of the type, size, and number of conductors specified.

Electric Cable Art. 824.02

**824.02 Materials.** Materials shall be according to the following Articles of Section 1000 - Materials:

# **CONSTRUCTION REQUIREMENTS**

**824.03** Installation. The electric cable may be installed in a trench, in a conduit, or aerially suspended, as indicated on the plans. When installed in a trench, the electric cable shall have a minimum depth of 750 mm (2.5 ft.) or 600 mm (2 ft.) as indicated on the plans.

The color coded conductor shall be connected according to the following schedule:

(a) Signal Cable - Signal Head (5 Conductor or 7 Conductor)

Conductor No.	Base Color	Tracer Color	Connection
1	Black		
2	White		AC, Neutral
3	Red		Red Circle Indication (AC,Line)
4	Green		Green Circle Indication (AC,Line)
5	Orange		Yellow Circle Indication (AC,Line)
6	Blue		Yellow Arrow Indication (AC,Line)
7	White	Black	Green Arrow Indication (AC,Line)

(b) Signal Cable - Pedestrian Signal Head

Conductor No.	Base Color	Tracer Color	Connection
1	Black		
2	White		AC, Neutral
3	Red		Don't Walk (AC,Line)
4	Green		Walk (AC.Line)

(c) Signal Cable - Pedestrian Push-Button

Conductor No.	Base Color	Tracer Color	Connection	
1 2	Black White		24 V DC Cabinet Logic Ground	

# Electric Cable

(d) Lead-in Cable (Single-Pair)

	Conductor No.	Color	Connection
	1 2	Black Non-Black	Loop Detector - Loop Signal Loop Detector - Loop Neutral
(e)		ation Cable or Lead	I-in Cable (Multipair)
	Conductor No. (Each Pair)	Color	Connection
	1 2	Black Non-Black	Signal Neutral/Logic Ground
(f)	Service Ca	able	
	Conductor No.	Color	Connection
	1 2	Black White	AC, Line AC, Neutral

The length of cable slack shall be provided according to the following schedule:

<u>Location</u>	Length of S	Slack Cable
	meters	(feet)
Gulfbox	0.5	1.5
Junction Box	0.5	1.5
Handhole	2.0	6.5
Double Handhole	4.0	13.0

Cable splices shall be made only at connections to detector loops or at the locations specified on the plans. When making a cable splice, the following procedures shall be used.

- (a) Remove all outer cable coverings, leaving 100 mm (4 inches) of insulated wire exposed.
- (b) Remove insulation for 25 mm (1 inch) and scrape copper conductors.
- (c) Connect conductors by twisting and soldering together.
- (d) Wrap each conductor separately with rubber or vinyl electrical tape. The wrapping shall completely cover the twisted connection and the insulation 25 mm (1 inch) beyond all exposed copper wire on either end of the connection.
- (e) Scrape the cable sheath clean and place the cable in a rigid mold or a container. The mold or container shall be of a type acceptable to the Engineer.
- (f) Center all conductors in mold or containers.
- (g) Fill the mold or container with epoxy resin or polyurethane compound. The

epoxy resin or polyurethane compound used shall be dielectric, waterproof, and approved by the Engineer.

All stranded conductors shall be terminated in the cabinet using crimp-on connectors.

Electric cables shall be pulled into conduit by training the cables at the entrance to the conduit to prevent twisting or overlapping. Detector lead-in cables shall be placed on top of signal cables. When 3 or more cables are pulled into a conduit, a fast-drying, water based lubricant recommended by the cable manufacturer shall be applied on the cables.

**824.04 Method of Measurement.** Electric cable will be measured for payment in meters (feet) in place. The length of measurement shall be the distance horizontally and vertically measured between the changes in direction, including cables in mast arms, mast arm poles, signal posts, and slack cables. The vertical cable length shall be measured according to the following schedule:

<u>Location</u>	Cable <u>Length</u>
Foundation (signal post, mast arm pole, controller cabinet) Mast Arm Pole	1 m (3 ft.)
(mast arm mounted signal head)	6 m (20 ft.)
Mast Arm Pole (bracket mounted signal head	4 m (13 ft.)
attached to mast arm pole) Signal Post	4 111 (13 11.)
(bracket or post mounted signal head)	4 m (13 ft.)
Pedestrian Push Button	2 m (6 ft.)

**824.05** Basis of Payment. This work will be paid for at the contract unit price per meter (foot) for ELECTRIC CABLE of the type, size, and number of conductors specified.

The lengths of slack cable allowed and the vertical cable allowed will be paid for at the contract unit price per meter (foot) for ELECTRIC CABLE IN CONDUIT.

The type specified will indicate the method of installation and whether the electric cable is Service, Signal, Lead-in or Communication.

## **SECTION 825. FIBER OPTIC CABLE**

- **825.01 Description.** This work shall consist of furnishing and installing all accessories required and the fiber optic cable of the type, size and number of fibers specified.
- **825.02 Materials.** Materials shall be according to the following Articles of Section 1000 Materials:

	Item	Article	e/Section
(a)	Fiber Optic Cable		1085.54

**825.03** Contractor Qualifications. The fiber optic cable installation shall be supervised by trained and experienced personnel. The cable terminations and splices shall be made by qualified technicians. Upon request by the Engineer, the Contractor shall provide documentation on qualifications and experience for fiber optic equipment installations. The Engineer will determine if the Contractor is qualified to perform the work.

### CONSTRUCTION REQUIREMENTS

### 825.04 Cable Installation.

- (a) General. The fiber optic cable shall be installed in continuous runs between controller cabinets or as marked on the plans. No splices shall be allowed outside the controller cabinet. The cable end shall be secured inside the controller cabinet so no load is applied to the exposed fiber strands.
  - (1) Cable Minimum Bend Radius. For static storage, the cable shall not be bent at any location to less than ten times the diameter of the cable outside diameter or as recommended by the manufacturer. During installation, the cable shall not be bent at any location to less than fifteen times the diameter of the cable outside diameter or as recommended by the manufacturer.
  - (2) Cable Slack. Slack cable shall be left in each handhole and double handhole, at the top of each conduit riser, and at each wood support pole according to the following requirements. Storage of additional slack cable in each handhole shall be coiled. These slack coils shall be bound at a minimum of 3 points around the coil perimeter and supported in their static storage positions. Storage of additional slack cable adjacent to conduit risers and support poles shall be as detailed on the plans. The minimum slack amounts shall be as follows.

Slack Cable	e Length
meters	feet
0.5	1.5
0.5	1.5
2.0	6.5
4.0	13.0
4.0	13.0
4.0	13.0
	meters 0.5 0.5 2.0 4.0 4.0

- (3) Cable Termination. Field cable shall terminate in the controller cabinet within a wall-mounted distribution enclosure according to Article 864.03.
- (b) Installation in Conduits and Ducts. A suitable cable feeder guide shall be used between the cable reel and the face of the conduit/duct to protect the cable and to guide it into the conduit off the reel. The cable shall be carefully inspected for jacket defects. If defects are noticed, the pulling operation shall be stopped immediately and the Engineer shall be notified.

Precautions shall be taken during installation to prevent the cable from being "kinked" or "crushed". A pulling eye shall be attached to the cable and used to pull the cable through the conduit. A pulling swivel shall be used to eliminate twisting of the cable. As the cable is played off the reel into the cable feeder guide, it shall be lubricated with a type of lubricant recommended by the cable manufacturer. The lubricant used shall be of water based type and approved by the cable manufacturer. Dynamometers or break away pulling swing shall be used to ensure that the pulling line tension does not exceed the installation tension specified by the cable manufacturer. Maximum length of cable pulling tensions shall not exceed the cable manufacturer's recommendations. The mechanical stress placed on a cable during installation shall not be such that the cable is twisted or stretched. The pulling of the cable shall be hand assisted at each controller cabinet. The cable shall not be crushed, kinked or forced around a sharp corner. Sufficient slack shall be left at each end of the cable to allow proper cable termination. At the controller cabinet and at the handhole the cable shall be visibly marked/tagged as "CAUTION-FIBER OPTIC CABLE".

- (c) Installation on Aerial Spans. The fiber cable shall be lashed onto the aerial support span wire. The aerial support shall be existing span wire, or new span wire according to Section 826. When the existing interconnect is supported by messenger cable and hanger rings, the rings and interconnect cable shall be removed. Existing conduit risers designated for re-use with the fiber optic interconnect shall have the existing weatherhead removed. Removal of these items shall be included in the cost of the fiber optic cable. The fiber optic cable shall be secured to the support cable by lashing with a "cable lasher". The lashing wire shall be a dielectric lashing filament to prevent the conductance or attraction of lightning. The lashing wire shall be securely tied off when terminated near each support pole.
- (d) Cable Placement into Conduit Risers. Kellum grips and/or other hanger devices shall be used to support the vertical drop of the cable and to prevent any possible kinking of the cable after installation. The top of the risers shall have a hexnut type watertight service entrance connector with an oval shaped grommet. The grommet shall be either neoprene or rubber. The voids between the fiber optic cable(s) and the grommet shall be sealed with silicone.

The fiber optic cable shall be tested according to Article 801.14(b).

- **825.05 Method of Measurement.** Cable will be measured for payment in meters (feet) in place. Cable will be measured horizontally and vertically between the changes in direction, including slack cables and the cable in the vertical conduit riser. The cable length in the foundations of a controller cabinet and a vertical pole will be accounted as 1 m (3 ft.) each.
- **825.06 Basis of Payment.** This work will be paid for at the contract unit price per meter (foot) for FIBER OPTIC CABLE of the type, size, and number of fibers specified.

The lengths of slack cable allowed and the vertical cable in the foundations and the cable in the vertical conduit riser will be paid for at the contract unit price per meter (foot) for FIBER OPTIC CABLE IN CONDUIT. The length of the cable on aerial span will be paid for at the contract unit price per meter (foot) for FIBER OPTIC CABLE ON MESSENGER.

The type specified will indicate whether the cable is installed in conduit or on messenger. The cable warning tags will be included in the cost of the fiber optic cable.

### **SECTION 826. SPAN WIRE AND TETHER WIRE**

- **826.01 Description.** This work shall consist of furnishing and installing span wire or tether wire and accessories.
- **826.02 Materials.** Materials shall be according to the following Articles of Section 1000 Materials:

Item	Article/Section
(a) Span Wire and Tether Wire	

### CONSTRUCTION REQUIREMENTS

- **826.03 Installation.** The span wire or tether wire with accessories shall be installed according to the details shown on the plans.
- **826.04 Method of Measurement.** Span wire and tether wire will be measured for payment in meters (feet) in place. Measurements will be along the horizontal distances between the supporting poles.
- **826.05 Basis of Payment.** This work will be paid for at the contract unit price per meter (foot) for SPAN WIRE or TETHER WIRE.
- Any additional span wire or tether wire required for sag and wrap-around shall be included in the cost of the wire specified.

### POLES AND POSTS

### **SECTION 830. METAL LIGHT POLES**

**830.01 Description.** This work shall consist of furnishing and installing a metal light pole complete with a mast arm, when specified, and all required hardware including bolt covers.

**830.02 Materials.** Materials shall be according to the following Articles of Section 1000 - Materials:

	Item Artic	le/Section
(a)	Light Pole	. 1085.30
(b)	Mounting Pad	. 1085.09

**830.03** Installation. The light pole shall be set plumb on the foundation with the use of leveling nuts. On bridge parapet walls, a vibration mounting pad shall be installed between the foundation leveling plate and the light pole. The pole shall be set with proper orientation of the access handhole. Poles shall not be left in place without mast arms and luminaires. The mast arm or arms shall be set at right angles to the centerline of the pavement.

Lighting unit identification numbers shall be installed before the lighting unit is energized.

**830.04** Basis of Payment. This item shall be paid for at the contract unit price each for LIGHT POLE, of the type, mounting height, and mast arm (quantity and length) type specified.

When breakaway devices are specified the devices will be paid for separately.

# **SECTION 831. WOOD POLE**

- **831.01 Description.** This work shall consist of furnishing and installing a wood pole as shown on the plans, including all necessary hardware and accessories required for the intended temporary or permanent use of the pole.
- **831.02 Materials.** Materials shall be according to the following Articles of Section 1000 Materials.

	Item	Article/Section
(a)	Wood Pole Lighting	
(b)	Wood Pole Signals	

### 831.03 Installation.

(a) Highway Lighting. Previously used poles and appurtenant items will be acceptable under this item, upon physical inspection and approval by the Engineer.

Poles shall be in good condition as acceptable to the Engineer and shall be according to the applicable ANSI requirements for sweep, crook, defects

and mechanical damage. Poles deemed unacceptable by the Engineer shall be removed from the jobsite.

Hardware shall also be made available for inspection by the Engineer and hardware deemed defective by the Engineer shall be removed from the job site and replaced with approved hardware. Hardware shall include cable hardware as well as pole hardware including insulators, cable supports, guy anchors, guy wires and the like.

As a minimum, pole guying shall be provided where indicated on the plans and at every dead-end pole and at any pole having non-offsetting cable support stresses.

Where mast arm equipment is indicated, the equipment shall be structurally sound and of the length and type specified. The Contractor shall obtain inspection and approval by the Engineer for any mast arm equipment. Where two luminaires are indicated as mounted on a common mast arm, a suitable duplex tenon adapter, complete with any required additional bracing shall be provided.

Poles shall be stored and handled according to ANSI 05.1.

Removal of all material and equipment furnished under this item shall not be included in this item.

- (b) Traffic Signals. The depth of the pole in the ground shall not be less than 20 percent of the pole length with a minimum of 1.8 m (6 ft.). With span wire type installations, down guys or sidewalk guys shall be installed as shown on the plans, and the pole shall be raked 300 mm (1 ft.). The backfill shall be tamped and compacted around the pole in 150 mm (6 inch) layers.
- **831.04** Basis of Payment. The work for highway lighting poles will be paid for at the contract unit price each for TEMPORARY WOOD POLE or WOOD POLE, of the length, class, mast arm quantity, and length indicated.

The work for traffic signal wood poles will be paid for at the contract unit price each for TRAFFIC SIGNAL WOOD POLE of the length and class specified.

# **SECTION 832. TRAFFIC SIGNAL POST**

- **832.01 Description.** This work shall consist of furnishing a metal traffic signal post of the length specified and installing it on a concrete foundation.
- **832.02 Materials.** Materials shall be according to the following Articles of Section 1000 Materials:

Item	Article/Section
(a) Traffic Signal Post	1085.41
(b) Concrete	1020

#### CONSTRUCTION REQUIREMENTS

**832.03 Installation.** The traffic signal post shall be erected plumb, securely bolted to a concrete foundation, and grounded to a ground rod according to the details shown on the plans. No more than 20 mm (3/4 inch) of the post threads shall protrude above the base. The vertical clearance between the bottom of a bracket or post mounted signal head or pedestrian signal head and the crown of the pavement shall be between 2.5 m (8 ft.) and 4.5 m (15 ft.).

When the signal head is not mounted on the top of the post, a pipe cap shall be furnished and installed on the top of the post. The Contractor shall apply an anti-seize paste compound on all nuts and bolts prior to assembly.

Prior to the assembly, the Contractor shall apply two additional coats of galvanized paint on the threads of the post and the base. The Contractor shall use a fabric post tightner to screw the post to the base.

**832.04** Basis of Payment. This work will be paid for at the contract unit price each for TRAFFIC SIGNAL POST of the type and length specified.



When a particular kind of material is specified for the post and base assembly, the work will be paid for at the contract unit price for TRAFFIC SIGNAL POST, PAINTED STEEL, TRAFFIC SIGNAL POST, GALVANIZED STEEL, or TRAFFIC SIGNAL POST, ALUMINUM.

#### SECTION 833. PEDESTRIAN PUSH-BUTTON POST

- **833.01 Description.** This work shall consist of furnishing a pedestrian push-button post and installing it on a concrete foundation.
- **833.02 Materials.** Materials shall be according to the following Articles of Section 1000 Materials:

Item	Article/Section
(a) Pedestrian Push-Button	1085.42
(b) Traffic Signal Post	1085.41
(c) Concrete	1020

#### CONSTRUCTION REQUIREMENTS

**833.03 Installation.** The pedestrian push-button post shall be installed plumb on a concrete foundation according to the details shown on the plans. The Contractor shall apply an anti-seize paste compound on all nuts and bolts prior to assembly.

The foundation shall be made of Class SI Concrete.

**833.04** Basis of Payment. This work will be paid for at the contract unit price each for PEDESTRIAN PUSH-BUTTON POST, TYPE I or PEDESTRIAN PUSH-BUTTON POST, TYPE II.

When a galvanized post is specified, the work will be paid for at the contract unit price each for PEDESTRIAN PUSH-BUTTON POST, TYPE I, GALVANIZED or PEDESTRIAN PUSH-BUTTON POST, TYPE II, GALVANIZED.



# SECTION 834. MAST ARM ASSEMBLY AND POLE

- **834.01 Description.** This work shall consist of furnishing a steel mast arm assembly and pole of the arm length specified and installing it on a concrete foundation.
- **834.02 Materials.** Materials shall be according to the following Articles of Section 1000 Materials:

Item	Article/Section
(a) Mast Arm Assembly and Pole	

#### CONSTRUCTION REQUIREMENTS

**834.03 Installation.** The components of a mast arm assembly and pole shall be assembled and erected according to the details shown on the plans. The pole shall be erected vertically on a concrete foundation. The Contractor shall furnish and install the required nuts and washers for mounting and plumbing the pole on the anchor bolts. After the entire assembly has been aligned and plumbed, a stainless steel mesh 6 mm (1/4 inch) maximum opening with a minimum wire diameter 1.5 mm (AWG No. 16) shall be stainless steel banded to the anchor bolts with a minimum 50 mm (2 inch) lap to enclose the void between the mast arm base plate and the concrete foundation. The pole shall be grounded according to Article 801.20(b).

The Contractor shall take precautions to avoid scratching the galvanized coating on the mast arm pole and assembly during the transportation and erection. If it is scratched, the Contractor shall touch up the scratches to the galvanized coating with a same color galvanized paint recommended by the pole manufacturer. The Contractor shall apply an anti-seize paste compound on all nuts and bolts prior to assembly.

A combination mast arm assembly and pole shall not be installed without the luminaire.

**834.04** Basis of Payment. This work will be paid for at the contract unit price each for STEEL MAST ARM ASSEMBLY AND POLE or STEEL COMBINATION MAST ARM ASSEMBLY AND POLE of the signal arm length specified.

#### **SECTION 835. LIGHT TOWER**

- **835.01 Description.** This work shall consist of furnishing and installing a light tower complete with lowering device, and all appurtenances required for a complete operating unit and installing it on a concrete foundation.
- **835.02 Materials.** Materials shall be according to the following Articles of Section 1000 Materials:

		Item	Article/Section
ĺ	(a)	Light Tower	1085.32
ĺ	(b)	Light Pole Identification	1085.05
İ	(c)	Ladder Set	1085.32(i)

#### CONSTRUCTION REQUIREMENTS

**835.03** Submittals and Certifications. Shop drawings, product data and certifications shall be submitted to the Engineer for approval. The submitted information shall be complete and shall include information relative to all specified requirements suitable for verification of compliance.

In general, light tower submittal information shall be dated, current, project specific, identified as to the project, and shall include the following:

- (a) Dimensioned shaft drawings and details.
- (b) Shaft design calculations, including Registered Engineer Certification.
- (c) Shaft material data, including finish information.
- (d) Welding details and procedures.
- (e) Letter of intent to provide specified weld inspection reports.
- (f) Confirmation of coordination between anchor bolt supplier and tower manufacturer for adequacy of anchor bolt assembly.
- (g) Manufacturer's recommended installation procedures.
- (h) Letter of intent to provide manufacturer's representative during installation and to provide specified installation certification.
- (i) Letter of intent to meet specified prototype sample requirements.
- **835.04 Prototype Light Tower.** The Contractor shall establish a working prototype tower which shall be in full compliance with these specifications to serve as physical confirmation of a working design and to provide a construction standard of reference of the towers included in the contract.

The prototype unit shall be installed as one of the units, required by the contract. The selection of the unit to be the prototype will be made by the Engineer.

The Contractor shall notify the Engineer of the timing of all installation operations of the prototype unit, including the foundation, to assure adequate inspection. At least 5 days notice will be provided to the Engineer by the Contractor prior to inspection. Any work done without such notice will be subject to removal and reinstallation, subject to the discretion of the Engineer.

Electric service to the prototype unit for demonstration purposes shall be provided by the Contractor.

Luminaires as specified for the contract or appropriate counterweights shall be installed, as directed by the Engineer. The luminaire ring shall be fully loaded, using counterweights as necessary for all luminaire positions not having luminaires. If counterweights are used in lieu of luminaires, the counterweights shall be installed and removed when luminaires are installed later, at no additional cost to the contract.

The installed prototype unit shall be tested for proper alignment and operation by the manufacturer and the Contractor. When the unit is complete and operational, the Contractor shall request, in writing, an approval inspection by the Engineer. At least 5 days notice from the receipt of the request shall be provided.

During the inspection, representatives of the Contractor and the manufacturer shall be present and the Contractor shall have personnel present to demonstrate connection, alignment, and operation of the unit.

Any deficiencies or defects found during the inspection will be itemized by the Engineer in writing and presented to the Contractor within 5 days of the inspection. After items needing correction are addressed, the Contractor shall request another inspection, as specified above, and this process shall be repeated until all deficiencies and defects are corrected and the prototype unit is approved.

No other tower units shall be erected at the jobsite until the prototype unit has been approved.

**835.05 Shipment and Installation.** The light tower, luminaire ring, etc., and hardware shall be packaged during shipment to protect all surfaces from being scratched, marred, chipped, or damaged in any way. Any minor damage to the light tower surfaces shall be touched up in a professional manner as approved by the paint manufacturer with protective coating solutions as provided by the manufacturer of the light tower at no additional cost to the Department. Any major damage to the light tower shall be repaired at the manufacturer's place of business or it shall be replaced. The Engineer will be the sole judge of the extent of any such damage and the adequacy of repair.

Prior to installation, the tower and all its components shall be inspected by the manufacturer's representative in the presence of the Engineer. Any parts found to be defective shall be repaired or replaced.

Each light tower shall be assembled and installed upon its foundation according to the manufacturer's recommendations and under the supervision of a representative of the manufacturer.

The tower shall be set plumb on the foundation and fastened to the anchor bolts with double nuts and washers. Flat washers shall be installed below and above the base plate of the pole. Lockwashers shall be installed on top of the top flat washer. The nuts shall be tightened in compliance with torque specifications recommended by the manufacturer of the lighting unit.

The space between the finished top of the foundation and the bottom of the base plate of the pole shall be enclosed with an expanded metal screen made of stainless steel. The size of the mesh of the screen shall be 6 mm (1/4 inch) or less, 1.22 mm (#18 gage) thick, or heavier as approved by the Engineer. The screen shall be held in place with a stainless steel band installed around the tower base plate. The band shall be held tight by a ratchet-type device. Grouting shall not be used to enclose the above described space.

As applicable, dynamometers, calibrated within the last year, shall be employed by the Contractor for measuring the applied force during field assembling.

The light tower shall be straight and centered on its longitudinal axis, under no-wind conditions, so when examined with a transit from any direction, the deviation from the normal shall not exceed 2 mm in 1 m (1/8 inch in 5 ft.) within any 1.5 m (5 ft.) of height, with total deviation not to exceed 75 mm (3 inches) from the vertical axis through the center of the pole base.

The manufacturer shall provide certification, signed by the supervising

representative, that each tower has been properly installed.

**835.06** Ladder Set. When specified, a ladder set shall be delivered to the storage facility located within the District. The ladder set shall be unloaded and stacked as directed by the Engineer. Wood blocking or other supports and appurtenant items will be required.

Each set shall be comprised of the specified number of ladders for the specified mounting as indicated in the following table:

Light Tower Mounting Height	Number of Ladder Sections Required for Each Set
24 m (80 ft.)	18
27 m (90 ft.)	20
30 m (100 ft.)	23
33 m (110 ft.)	25
36 m (120 ft.)	27
40 m (130 ft.)	29
42 m (140 ft.)	32
45 m (150 ft.)	34

**835.07** Basis of Payment. This work, including the prototype unit, will be paid for at the contract unit price each for LIGHT TOWER of the mounting heights and luminaire mounting positions specified.

The concrete foundation and luminaires will be paid for according to Sections 837 and 844, respectively.

The ladder set, when specified, will be paid for at the contract unit price each for LADDER SET, for the mounting height specified.

#### **SECTION 836. LIGHT POLE FOUNDATION**

**836.01 Description.** This work shall consist of furnishing and installing a light pole foundation.

**836.02 Materials.** Materials shall be according to the following Articles of Section 1000 - Materials:

	Item	Article/Section
(a)	Item Concrete (Note 1)	1020
(b)	Reinforcement Bars	1006.10
(c)	Conduit	1085.15
(d)	Anchor Bolts	1085.10
(e)	Metal Light Pole Foundation	1085.31
	Calcium Nitrite Corrosion Inhibitor	

Note 1: Class SI Concrete shall be used

# Note 2: For Inground Foundations

## **CONSTRUCTION REQUIREMENTS**

#### 836.03 Installation.

(a) Concrete in Ground Foundations. The foundation depths shall be as directed by the Engineer based upon evaluation of the soil conditions encountered. The Engineer may determine soil condition by visual inspection or, by the use of a pocket pentrometer and will establish foundation depth based upon the Foundation Depth Table shown on the plans.

The hole for the foundation shall be made by drilling with an auger, of the same diameter as the foundation. If soil conditions require the use of a liner to form the hole, the liner shall be withdrawn as the concrete is deposited. The top of the foundation shall be constructed level. A liner or form shall be used to produce a uniform smooth side to the top of the foundation. Foundation top shall be chamfered 20 mm (3/4-inch).

Foundations shall not protrude more than 100 mm (4 inches) above the finished grade within a 1.5 m (5 ft.) chord above the foundation. If foundation heights including anchor bolts, extend beyond these specified limits, the foundation shall be replaced at the Contractors expense.

The steel reinforcement, raceway, and anchor bolts shall be secured and properly positioned in the augered hole so after pouring concrete the components shall retain their proper positions.

(b) Concrete Barrier Wall Foundations. The top portion of the foundation shall be integrated with a portion of barrier wall or barrier retaining wall, as one monolithic structure, as shown on the plans and as directed by the Engineer. This portion of the foundation shall be of the same shape as the wall. Any required sheeting, cribbing or other associated work required to complete the foundation work shall be included. The length of wall included shall be 2.4 m (8.0 ft.).

Concrete shall be deposited against the soil. If the soil condition require the use of a liner to form the hole, the liner shall be withdrawn as the concrete is deposited. The top of the foundation shall be constructed level.

The steel reinforcement, raceway, and anchor bolts shall be secured and properly positioned in the augered hole so after pouring concrete, the components shall retain their proper positions.

Expansion couplings as detailed in the plans shall be used at the expansion joints at either end of the foundation.

(c) Metal Foundations. The foundation shall be installed with its axis plumb. The light pole shall be installed plumb without the use of shims, grout, or other leveling devices. The base plate shall be not more than 25 mm (1-inch) above with the highest point of adjacent final grade.

Any voids within the metal screw-in foundation shall be filled with fine

aggregate.

Wiring slots shall be oriented to be parallel to the roadway unless otherwise directed by the Engineer to achieve alignment with grade or to minimize bends in the feeder wiring into the foundation oriented parallel to the roadway.

The pole foundations which are not installed according to the specified requirements shall be adjusted or replaced after final grading at no additional cost.

#### 836.04 Method of Measurement.

- (a) Concrete In-Ground Foundations. The foundation shall be measured for payment in meters (feet) of the foundation in place, in accordance with the total length of concrete foundation required, indicated as foundation depth, on the plans and as directed by the Engineer. Extra foundation depth, beyond the directive of the Engineer, will not be measured for payment.
- (b) Concrete Barrier Wall Foundations. The foundation shall be measured for payment in meters (feet) of the foundation in place, from the bottom of the foundation to the bottom of the barrier wall as directed by the Engineer. Extra foundation depth, beyond the directive of the Engineer, will not be measured for payment.

The barrier wall through the foundation, including the section through the above-grade reinforcement steel, anchor bolts, raceway extensions, and the ground rod shall be measured and paid for separately as concrete barrier wall.

**836.05** Basis of Payment. This work will be paid for at the contract unit price per meter (foot) for LIGHT POLE FOUNDATION, of the type and diameter indicated, or each for POLE FOUNDATION, METAL, of the diameter, length, and bolt circle/slot indicated.

## **SECTION 837. LIGHT TOWER FOUNDATION**

- **837.01 Description.** This work shall consist of furnishing and installing concrete foundation for the installation of a light tower.
- **837.02 Materials.** Materials shall be according to the following Articles of Section 1000 Materials:

	Item	Article/Section	
(a)	Portland Cement Concrete	1020	
(b)	Reinforcement Bars	1006.10	
(c)	Conduit	1085.15	
(d)	Light Tower Anchor Bolt Assembly	1085.33	

## CONSTRUCTION REQUIREMENTS

**837.03 General.** The top of the foundation to 450 mm (18 inches) below grade shall be formed. Each foundation shall be poured monolithically. The reinforcing cage, anchor bolts, and wireway shall be accurately held in place by the form. The anchor bolts shall be held plumb above the top of the foundation.

A concrete work pad shall be provided as indicated in the plans as a part of this item.

The anchor bolt assembly may be factory fabricated with the reinforcing cage or it may be field assembled.

Material excavated shall be disposed of by the Contractor according to Article 202.03.

The concrete shall be placed and consolidated in the foundation according to Article 503.07 and the following procedure:

Surface water will not be permitted to enter the hole and all water which may have infiltrated into the hole shall be removed before placing concrete. If dewatering of the drilled hole cannot be accomplished without loss of soil or creating quick conditions, then the hole shall be lined with a suitable steel casing before concrete is placed. The casing shall be removed from the hole as concrete is placed. The bottom of the casing shall be maintained not more than 1.5 m (5 ft.) nor less than 300 mm (1 ft.) below the top of the concrete during withdrawal and placing operations. Separation of the concrete during withdrawal operations shall be avoided by hammering or otherwise continuously vibrating the casing.

If conditions develop that prohibit the total removal of the steel casing during concrete placement, then the foundation shall be abandoned. The Engineer will establish a new location for the foundation. The abandoned foundation and adjoining area shall be backfilled, graded, and seeded to the satisfaction of the Engineer.

As an option to this procedure, the Contractor may submit for review and approval by the Engineer alternate construction procedures according to the following parameters:

- (a) Stay-in-Place Casing. Install a suitable steel casing during the drilling operation, insuring continuous contact between the casing and undisturbed earth. If voids develop outside the casing, then the foundation shall be abandoned or the casing removed during concrete placement as required above.
- (b) Concrete Placement Under Water. Under certain soil conditions, a drilled hole containing ground water will remain stable provided the water is not removed. If this condition exists, the Contractor may propose placement of Class SC concrete according to Article 503.07 (a) to an elevation approximately 300 mm (1 ft.) above the ground water elevation. At this point, the excess water shall be removed by pumping or bailing without disturbing the in-place concrete. The remaining concrete shall be placed according to Article 503.07 using Class SI concrete. The drilled hole depth shall be increased 150 mm (6-inches) to allow for laitance which may

develop during the seal coat concrete placement. If the concrete being placed becomes contaminated with soil, the foundation shall be abandoned. The abandoned foundation shall be disposed of as required above.

The light tower shall not be erected until after the concrete has been cured according to Article 1020.13.

**837.04 Method of Measurement.** The foundation will be measured for payment in meters (feet) of light tower foundation in place.

Abandoned foundations will not be measured for payment. When the seal coat option is used, the additional 150 mm (6 inches) of foundation depth will not be measured for payment.

**837.05 Basis of Payment.** Foundations will be paid for at the contract unit price per meters (foot) for LIGHT TOWER FOUNDATION, which price shall include excavation or drilling, except excavation in rock, backfilling, concrete, disposal or excavated material, steel casing when required, form work, and furnishing all materials within the limits of the foundation, including the light tower anchor bolt assembly.

Excavation in rock will be paid for according to Section 502 for Rock Excavation for Structures.



# **SECTION 838. TRAFFIC SIGNAL CONCRETE FOUNDATION**

**838.01 Description.** This work shall consist of furnishing and installing a concrete foundation for the installation of a traffic signal post, controller base, or mast arm pole.

**838.02 Materials.** Materials shall be according to the following Articles of Section 1000 - Materials:

	Item	Article/Section
(a)	Ground Rod	1085.04
(b)	Concrete	1020
(c)	Reinforcement Bars	1006.10(a)

## CONSTRUCTION REQUIREMENTS

**838.03 General.** Concrete foundations of the type specified shall be constructed as shown on the plans. The top of the foundation shall be finished level. Shimming of the appurtenance to be attached will not be permitted. A form extending a minimum of 225 mm (9 inches) below the top surface of the foundation is required. The form shall be set level, and means shall be provided for holding it rigidly in place while the concrete is being deposited.

Where a concrete foundation is contiguous to a sidewalk, preformed joint filler of 12 mm (1/2 inch) thickness shall be placed between the foundation and the sidewalk.

All conduit in the foundation shall be installed rigidly in place before concrete is

deposited in the form. Bushings shall be provided at the ends of conduit. Anchor bolts and ground rod shall be set in place before the concrete is deposited by means of a template constructed to space the anchor bolts according to the pattern of the bolt holes in the base of the appurtenance to be attached.

- (a) Square or Rectangular Foundations. Whenever the excavation is irregular, a form shall be used to provide the proper dimension of the entire foundation below the ground surface.
- (b) Drilled Type Foundations. The hole for the foundation shall be made by drilling with an auger, of the same diameter as the foundation. If soil conditions require the use of a liner to form the hole, the liner shall be withdrawn gradually as the concrete is deposited.
- **838.04 Method of Measurement.** The foundation will be measured for payment in meters (feet) in place.
- **838.05** Basis of Payment. This work will be paid for at the contract unit price per meter (foot) of depth of CONCRETE FOUNDATION of the type specified, which price shall be payment in full for all necessary excavating or drilling, backfilling, disposal of unsuitable material, form work, and furnishing all materials within the limits of the foundation, except the anchor bolts.

When the contract does not contain a unit price for rock excavation for structures and rock is encountered, it will be paid for according to Article 109.04.

# SECTION 839. DRILL EXISTING FOUNDATION OR HANDHOLE

- **839.01 Description.** This work shall consist of drilling a hole in an existing concrete foundation or handhole and for furnishing and installing a new conduit.
- **839.02** General. The size of the hole shall be as close as possible to the size of the conduit. A conduit of the size required shall be installed in the drilled hole. A bushing shall be provided at the end of the conduit. The space between the conduit and the foundation shall be caulked with a waterproof grout.
- **839.03** Basis of Payment. This work will be paid for at the contract unit price each for DRILL EXISTING FOUNDATION or DRILL EXISTING HANDHOLE which price shall include all necessary excavation and backfilling outside of the foundation or handhole.



## SECTION 840. SIGNAL HEAD AND OPTICALLY PROGRAMMED SIGNAL HEAD

- **840.01 Description.** This work shall consist of furnishing and installing a signal head or an optically programmed signal head.
- **840.02 Materials.** Materials shall be according to the following Articles of Section 1000 Materials:

#### CONSTRUCTION REQUIREMENTS

**840.03 Installation.** The signal head or optically programmed signal head shall be installed on a post, bracket, span wire, or mast arm as shown on the plans. Other methods of attaching the signal head to a post, a mast arm pole, or a mast arm may be used upon approval by the Engineer. Signal heads consisting of only one face and up to 3 sections may be post mounted.

Each signal face shall be pointed in the direction of the approaching traffic it is to control and be aimed to have maximum effectiveness for an approaching driver located at a distance from the stop line equal to the normal distance traversed while stopping. The optically programmed signal face shall be veiled according to the visibility requirements at the direction of the Engineer.

The size of each signal lens shall be 300 mm (12 inch).

During construction and until the installation is placed in operation, all signal faces shall be hooded. The hooding material shall be securely fastened so it will not be disturbed by normal inclement weather or wind. The color of the hooding materials shall differentiate the signal as being hooded.

**840.04** Basis of Payment. This work will be paid for at the contract unit price each for SIGNAL HEAD or OPTICALLY PROGRAMMED SIGNAL HEAD of the type specified and of the particular material type when specified.

If a signal head with both conventional and optically programmed signal faces is required, it will be paid for as a COMBINATION SIGNAL HEAD.

The type specified will indicate the number of signal faces, the number of signal sections in each signal face, and the method of mounting.

## **SECTION 841. PEDESTRIAN SIGNAL HEAD**

- **841.01 Description.** This work shall consist of furnishing and installing a pedestrian signal head.
- **841.02 Materials.** Materials shall be according to the following Articles of Section 1000 Materials:

	Item Article	e/Section
(a)	Signal Head and Optically Programmed Signal Head	1085.37
(b)	Pedestrian Signal Head	1085.38

## **CONSTRUCTION REQUIREMENTS**

**841.03 Installation.** The pedestrian signal head shall be installed on a post or bracket as shown on the plans. Other methods of attaching the pedestrian signal head to a post or a mast arm pole may be used upon approval by the Engineer.

Each pedestrian signal face shall be aimed to provide maximum visibility at the beginning of the controlled crossing.

The size of the pedestrian signal face shall be Class 2, 3, or 4 according to the ITE Standards. All pedestrian signal faces of one intersection shall be of the same

Class and design.

During construction and until the installation is placed in operation, all pedestrian signal faces shall be hooded. The hooding material shall be securely fastened so it will not be disturbed by normal inclement weather or wind. The color of the hooding material shall differentiate the pedestrian signal faces as being hooded.

**841.04** Basis of Payment. This work will be paid for at the contract unit price each for PEDESTRIAN SIGNAL HEAD of the type and of the particular kind of material when specified.

The type specified will indicate the number of faces and the method of mounting.

# **SECTION 842. TRAFFIC SIGNAL BACKPLATE**

**842.01 Description.** This work shall consist of furnishing a traffic signal backplate and attaching it to a traffic signal face.

**842.02 Materials.** Materials shall be according to the following Articles of Section 1000 - Materials:

Item	Article	Section
(a) Traffic Signal Backplate		1085.39

## **CONSTRUCTION REQUIREMENTS**

**842.03 Installation.** The traffic signal backplate shall be securely attached to a traffic signal face with noncorrosive bolts, locknuts, and washers. At least one bolt shall be used on each side of a signal section in contact with the backplate.

**842.04** Basis of Payment. This work will be paid for at the contract unit price each for TRAFFIC SIGNAL BACKPLATE of the type and of the particular kind of material when specified.

#### SECTION 843. DIRECTIONAL LOUVER

- **843.01 Description.** This work shall consist of furnishing and installing a directional louver for a 300 mm (12 inch) signal lens in the signal heads.
- **843.02 Materials.** Materials shall be according to the following Articles of Section 1000 Materials:

ItemArticle/Section(a) Directional Louver1085.40

## CONSTRUCTION REQUIREMENTS

**843.03 Installation.** The directional louver shall provide an angle of cutoff on each side of the center axis of the light beam as follows:

Type A 0 degree
Type B 7 to 10 degrees
Type C 11 to 14 degrees

The directional louver shall be installed inside the signal visor in front of the signal lens and secured in place with a minimum of two metal screws.

**843.04** Basis of Payment. This work will be paid for at the contract unit price each for DIRECTIONAL LOUVER, of the type specified.

When used with a 200 mm (8 inch) lens, this work will be paid for at the contract unit price each for DIRECTIONAL LOUVER, of the type specified.

## **SECTION 844. LUMINAIRE**

- **844.01 Description.** This work shall consist of furnishing and installing a luminaire including branch circuit/extension pole wire as applicable, lamp, fuseholders, mounting hardware, and fusing.
- **844.02 Materials.** Materials shall be according to the following Articles of Section 1000 Materials:

		e/Section
(a)	Luminaire	1085.35
	Pole Wire	
(c)	Fuses & Fuseholder	1085.03
(d)	Lamps	1085.07
	Fasteners and Hardware	

## CONSTRUCTION REQUIREMENTS

**844.03 General Installation.** Each luminaire shall be installed according to the luminaire manufacturer's recommendations.

Luminaires which are pole mounted shall be mounted on site such that poles and mast arms are not left unloaded. Pole mounted luminaires shall be leveled/adjusted after poles are set and vertically aligned before being energized.

Each luminaire ballast and/or ballast arrangement shall be checked to assure compatibility with the project power system. When the luminaire has a multi-tap ballast, the tap shall be adjusted as necessary to assure a voltage match.

When the night-time check of the lighting system by the Engineer, indicates that any luminaires are mis-aligned, the mis-aligned luminaires shall be corrected at no additional cost. Should the photometric results of the luminaire indicate, in the judgement of the Engineer, a tilt adjustment is warranted, the adjustment shall be made at no additional cost.

No luminaire shall be installed before it is approved. Where independent testing is required, full approval will not be given until complete test results, demonstrating compliance with the specifications, have been reviewed and accepted by the Engineer.

Pole wire shall be extended through the pole, pole grommet, luminaire ring and any associated mast arm and tenon. The pole wire shall be terminated in a manner that avoids sharp kinks, pinching, pressure on the insulation, or any other arrangement prone to damaging insulation value and producing poor megger test results. Wires shall be trained away from heat sources within the luminaire. Wires shall be terminated so all strands are extended to the full depth of the terminal lug with the insulation removed far enough so it abuts against the shoulder of the lug, but is not compressed as the lug is tightened.

When mounted on a tenon, care shall be exercised to assure maximum insertion of the mounting tenon.

When installing the lamp or performing any other activity that requires opening of the optical assembly, care shall be exercised to avoid touching the reflector or allowing contaminants to enter the assembly. Each lamp and lens shall be free of all dirt, smudges, etc. Should the reflector or refractor require cleaning, a mild soap or non-abrasive detergent, containing no chlorinated or aromatic hydrocarbons, shall be used and then rinsed clean with cold water and wiped dry.

**844.04 Conventional Pole Installation.** When the pole is bridge mounted, a minimum size stainless steel 1/4-20NC set screw shall be provided to secure the luminaire to the mast arm tenon. A hole shall be drilled and tapped through the tenon and luminaire mounting bracket and then fitted with the screw.

For horizontal mounts, the luminaire shall be installed parallel to the plane of the roadway, taking into consideration the applicable grade and superelevation of the traveled lanes. When a horizontal mount high mast luminaire is used, on a conventional pole, the optics shall be set perpendicular to the traveled roadway.

**844.05 Highmast Installation.** Luminaires having asymmetrical photometric distributions shall be carefully oriented with respect to the roadway as indicated on the plans and as directed by the Engineer. The Contractor shall confirm all luminaire orientations with the Engineer prior to installation.

For horizontal mounts having rotating optical assemblies, after the orientation of each mast arm tenon is inspected and approved by the Engineer, the position shall be permanently marked in a manner acceptable to the Engineer. The luminaire shall then be leveled to the plane of the luminaire ring.

When the luminaire position and orientation has been confirmed and approved by the Engineer, the luminaire shall be anchored with a minimum size 1/4-20NC stainless steel set screw installed through tapped holes in the tenon and mounting bracket of the luminaire. Counterweights on un-used tenons shall be mounted in a similar manner.

Pre-installed wire on the tower ring shall have the ends of each wire capped at the tenon with butt type crimp connectors for un-used tenons. The wires shall then be re-inserted into the tenon end and the tenon end shall be capped.

**844.06 Underpass Installation.** When attached directly to a structure, the underpass luminaire shall have 25 mm (1 inch) stainless steel spacers installed between the luminaire and the structure.

An aluminum underpass luminaire numbering decal bracket for each underpass luminaire shall be installed as shown on the plan. The bracket shall be large enough

to accommodate the identification and shall be mounted on the pier or retaining wall from which the luminaires are electrically fed as directed by the Engineer.

When suspended, the underpass luminaire shall be installed 25 mm (1 inch) above the lowest underpass beam and shall be mounted parallel to the plan of the roadway, taking into consideration the applicable grade and superelevation of the traveled lanes. Vibration dampening assemblies shall be used and sized to the weight and shape of the underpass luminaire. All mounting hardware, except the vibration dampeners, shall be stainless steel.

**844.07 Sign Lighting Installation.** Each luminaire shall be mounted on the sign walkway structure with stainless steel hardware and with at least 3 points of attachment.

The center-to-center spacing of the luminaires will be determined by the Engineer. The end sections shall not exceed one-half the spacing between luminaires.

The mounting shall provide the correct position of the luminaire as recommended by the manufacturer and shall be able to withstand 130 km/h (80 mph) winds with a 1.3 gust factor.

Disabling brightness shall be shielded from traffic approaching either the front or back of the sign.

The mounted luminaire or mounting hardware shall not extend above the bottom of the sign or below the bottom of the walkway support.

**844.08** Basis of Payment. This work will be paid for at the contract unit price each for LUMINAIRE, of the type and wattage indicated, which shall be payment in full for the luminaire complete.

## **SECTION 845. NAVIGATION OBSTRUCTION FIXTURE**

- **845.01 Description.** This item shall consist of furnishing and installing a navigation obstruction warning fixture complete with all supports and hardware, wiring, and connections to the structure or pole, and appurtenant mounting accessories.
- **845.02 Materials.** Materials shall be according to the following Articles of Section 1000 Materials:

Item	Article/Section
(a) Waterway Obstruction Warning Luminaire	1085.35(f)
(b) Aviation Obstruction Warning Luminaire	1085.35(g)
(c) Fuseholders and Fuses	1085.03
(d) Pole Unit Identification	1085.05
(e) Lamps	1085 07

**845.03 Installation.** Mounting of the luminaire shall be as recommended by the luminaire manufacturer in such a manner that they clear all obstacles when retrieved for maintenance and relamping.

**845.04** Basis of Payment. This work will be paid for at the contract unit price each for WATERWAY OBSTRUCTION WARNING LUMINAIRE or AVIATION OBSTRUCTION WARNING LUMINAIRE of the type, wattage, and color indicated.

# **SECTION 846. INDUCTIVE LOOP DETECTOR**

- **846.01 Description.** This work shall consist of furnishing and installing an inductive loop detector.
- **846.02 Materials.** Materials shall be according to the following Articles of Section 1000 Materials:

## CONSTRUCTION REQUIREMENTS

- **846.03 Installation.** The inductive loop detector shall be installed inside a traffic signal controller cabinet. the detector shall be either card rack type or shelf-mounted type. The detector may be single-channel, two-channel, or four-channel.
- **846.04** Basis of Payment. This work will be paid for at the contract unit price each for INDUCTIVE LOOP DETECTOR or INDUCTIVE LOOP DETECTOR WITH SYSTEM OUTPUT, which price shall include the necessary connections and adjustments for proper operation.
- If the detector unit has more than one complete detection channel, each complete detection channel will be considered as a detector for payment.



# **SECTION 847. DETECTOR LOOP**

- **847.01 Description.** This work shall consist of furnishing and installing a detector loop in the pavement.
- **847.02 Materials.** Materials shall be according to the following Articles of Section 1000 Materials:

The detector loop and sealer shall be according to the recommendations of the manufacturer of the related inductive loop detector as needed for proper operation.

## CONSTRUCTION REQUIREMENTS

**847.03 Testing.** The detector loop shall be tested according to Article 801.14(b).

- **847.04 Installation.** The detector loop location, shape, size, and the number of turns shall be as shown on the plans or as recommended by the manufacturer of the related inductive loop detector. Multiple loops connected to the same detector channel shall be connected in series or as directed by the Engineer. The detector loop shall be installed in the pavement according to the details shown on the plans and the following requirements:
  - (a) Type I detector loop shall consist of furnishing a detector loop wire enclosed in a flexible tubing and installing it in a sawed slot in the pavement.

The sawed slot shall be clean, dry, and have a smooth bottom. Diagonal saw cuts or drilled holes shall be made at all corners to prevent sharp bends in the wire. The saw cuts at the corners shall be overlapped so they have full depth. The slot shall be cleaned by air pressure removing any debris and water, if any present. Each tube containing the loop wire shall be pushed into the saw cut with a wooden stick and not with any metal tool.

Retainers shall be added to the sawed slot to prevent the loop wires from "floating" during the pouring of the loop sealant. These retainers shall be 25 mm (1 inch) pieces of the tubing bent in half. The loop wires not embedded in the pavement shall be evenly twisted approximately 16 turns per meter (5 turns per foot).

(b) Type II detector loop shall consist of furnishing a mineral-insulated metal-sheathed cable, installing it on a bituminous or pcc base course and covering it with a bituminous surface course. The surface course shall be between 50 and 125 mm (2 and 5 inches) thick. The cable shall be secured to the base course by a method approved by the Engineer. Slanted holes shall be drilled through the base course. The leads shall be bound together with tie wraps or fish tape rope, inserted through the hole, and positioned in place to make splices in the junction box or handhole.

The end of the cable shall be stripped, insulated and installed in a sleeve assembly according to the manufacturer's instructions to prevent moisture from entering the cable. The sleeved conductors shall be spliced together to form one continuous length. As each splice is made, it shall be metered to ensure a proper connection. The conductors must be soldered together and each conductor completely wrapped with two layers of rubber or vinyl electrical tape.

- (c) Type III detector loop shall consist of furnishing a detector loop wire sealed with asphalt rubber inside a rigid plastic conduit and installing it on a bituminous or pcc base course and covering it with a bituminous surface course. The surface course shall be between 50 and 125 mm (2 and 5 inches) thick. The conduit shall be secured to the base course by a method approved by the Engineer. Slanted holes shall be drilled through the base course. The plastic conduit shall be inserted through the hole toward the junction box or handhole.
- **847.05 Method of Measurement.** This work shall be measured for payment in meters (feet) in place. Type I detector loop shall be measured along the sawed slot in the pavement containing the loop and lead-in, rather than the actual length of the wire. Type II and Type III detector loops shall be measured along the detector loop and lead-in embedded in the pavement, rather than the actual length of the wire.

**847.06** Basis of Payment. This work will be paid for at the contract unit price per meter (foot) for DETECTOR LOOP of the type specified.

## **SECTION 848. ILLUMINATED SIGN**

- **848.01 Description.** This work shall consist of furnishing and installing an illuminated sign with the lamp intensity control device and the step-down transformer for the fiber-optic sign.
- **848.02 Materials.** Materials shall be according to the following Articles of Section 1000 Materials:

Item	Article/Section
(a) Illuminated Sign	

**848.03** Basis of Payment. This work will be paid for at the contract unit price each for ILLUMINATED SIGN, FLUORESCENT or ILLUMINATED SIGN, FIBER-OPTIC.

## SECTION 849. TEMPORARY TRAFFIC SIGNAL

**849.01 Description.** This work shall consist of furnishing, installing, maintaining, and removing a temporary traffic signal installation as shown on the plans.

## **CONSTRUCTION REQUIREMENTS**

- **849.02 Installation.** The Contractor shall notify the Engineer at least 48 hours in advance when the temporary signal installation is ready to be activated. The Engineer will then inspect the installation. After approval by the Department, the maintenance of the temporary signal installation, including all energy charges, shall become the responsibility of the Contractor until removal is directed by the Engineer. After the removal of the temporary installation, the equipment and materials furnished by the Contractor shall remain the property of the Contractor.
- **849.03 Maintenance.** The temporary traffic signal maintenance shall be according to Article 801.13.
- **849.04** Basis of Payment. This work will be paid for at the contract unit price each for TEMPORARY TRAFFIC SIGNAL INSTALLATION. Each intersection will be paid for separately.

Sixty percent of the bid price will be paid following approval of each installation. The remaining 40 percent will be paid following removal of each installation.

## SECTION 850. MAINTENANCE OF EXISTING TRAFFIC SIGNAL INSTALLATION

**850.01 Description.** This work shall consist of maintaining an existing traffic signal installation that has been designated to remain in operation during construction.

**850.02 Procedure.** The energy charges for the operation of the traffic signals will be paid for by the Department or the local agency.

At least one week prior to beginning construction within 125 m (400 ft.) of the signalized intersection, the Contractor shall conduct a signal inspection with a representative of the agency responsible for the signal maintenance. The signal inspection shall reveal defective existing traffic signal items such as inductive loop detectors, lead-in cable, detector loop, interconnect cable and so forth, and the Contractor shall not be held responsible for these items. In case the Contractor fails to contact the signal maintaining agency for the signal inspection, the Contractor shall be held responsible for all the signal items remaining defective at the completion of the construction.

The Contractor shall become responsible for the maintenance of the existing signalized intersection at a date mutually agreed upon between the Contractor and the signal maintaining agency representative but no later then the beginning of construction by the Contractor within 125 m (400 ft.) of the intersection. The Contractor's signal maintenance responsibility shall cease upon the issuance of a Signal Acceptance Notice by the Engineer.

**850.03 Maintenance.** The maintenance shall be according to Article 801.13 and the following:

The Contractor shall be responsible for the controller programming to provide for safe and efficient signal operation during construction. The Contractor may seek assistance from the maintaining agency personnel on the appropriate controller settings.

**850.04 Basis of Payment.** This work will be paid for at the contract unit price per week for MAINTENANCE OF EXISTING TRAFFIC SIGNAL INSTALLATION.

#### SECTION 851. PAINT EXISTING TRAFFIC SIGNAL EQUIPMENT

- **851.01 Description.** This work shall consist of cleaning and painting the existing traffic signal equipment reused as part of the new traffic signal installation.
- **851.02 Materials.** Materials shall be according to the following Articles of Section 1000 Materials:

- **851.03** Cleaning. Prior to painting, the surfaces shall be thoroughly cleaned of all surface irregularities and foreign materials, so the prime and paint coatings will have a smooth finish.
- **851.04 Painting.** After cleaning, one coat of an approved primer shall be applied to all areas where the old paint has been removed or damaged. On surfaces where small areas of metal at closely spaced intervals are exposed, the primer shall consist of a complete coating. The surface of the signal equipment shall be painted as follows:

# Art. 851.04 Paint Existing Traffic Signal Equipment

- (a) The signal housings, controller cabinet, signal posts (except bright aluminum posts) and brackets shall be painted with two coats of yellow enamel.
- (b) The signal doors, visors, and metal backplates shall be painted with two coats of dull (matte) black paint.
- (c) The steel mast arm assemblies and poles shall be painted with two coats of aluminum paint, when specified on the plans.



**851.05** Basis of Payment. This work will be paid for at the contract unit price each for PAINT EXISTING TRAFFIC SIGNAL EQUIPMENT.

## SECTION 852. EMERGENCY VEHICLE PRIORITY SYSTEM

- **852.01 Description.** This work shall consist of furnishing a light transmitter, furnishing and installing a light detector, or a light detector amplifier, for an emergency vehicle priority system.
- **852.02 Materials.** Materials shall be according to the following Articles of Section 1000 Materials:

**852.03 Installation.** The light transmitter shall be furnished to the user as directed by the Engineer.

The light detector shall be installed on or near a traffic signal head with necessary connections for proper operation, as indicated on the plans. The confirmation beacon shall be installed near the light detector or as indicated on the plans and shall face in the same direction as the corresponding light detector.

The light detector amplifier shall be installed inside a traffic signal controller cabinet or in the light detector housing.

**852.04** Basis of Payment. This work will be paid for at the contract unit price each for LIGHT TRANSMITTER, LIGHT DETECTOR, or LIGHT DETECTOR AMPLIFIER.

Furnishing and installing a confirmation beacon shall be included in the cost of the light detector.

# **CONTROLLERS AND DEVICES**

## **SECTION 855. LIGHTING CONTROLLER**

- **855.01 Description.** This work shall consist of furnishing and installing an electrical control cabinet with control device(s), distribution equipment, foundation, and wiring for control of roadway lighting.
- **855.02 Materials.** Materials shall be according to the following Articles of Section 1000 Materials:

	Item	Article	/Section
(a)	Control Equipment		1085.34
(b)	Ground Rod Access Well		1085.04

#### 855.03 Installation.

(a) General. The construction and installation shall be according to N.E.C. Article 373 and the N.E.S.C. The lighting controller installation shall be according to the details, location, and orientation shown on the plans.

A concrete work pad shall be provided in front of the cabinet, except where the cabinet faces sidewalk.

The Contractor shall confirm the orientation of the lighting controller, and its door side, with the Engineer, prior to installing the foundation.

All conduit entrances into the lighting controller shall be sealed with a pliable waterproof material.

- (b) Controller Mounted on Concrete Foundation. The lighting controller enclosure or pedestal shall be set plumb and level on the foundation. It shall be fastened to the anchor bolts with hot-dipped galvanized or stainless steel nuts and washers. Foundation mounted lighting controllers shall be caulked at the base with silicone.
  - Where the controller has a metal bottom plate, the plate shall be sealed as a rodent and dust/moisture barrier.
- (c) Controller Mounted on Pole. The lighting controller enclosure shall be mounted to the pole as shown on the plans. Aluminum brackets designed for pole mounting shall be used. Enclosures greater than 650 mm (26 inches) in height shall have stiffener plates on both top and bottom of the rear wall for mounting brackets. All mounting hardware shall be stainless steel.
- (d) Controller Mounted on Wall. The lighting controller enclosure shall be mounted to the wall with stainless steel fasteners as indicated in the plans. Stainless steel mounting brackets designed for wall mounting shall be used.
- **855.04** Ground Rod Access Well. The cover of the ground rod access well shall be installed flush with the adjacent level grade at the location indicated on the plans. Crushed stone or gravel shall be packed and filled to a point approximately 100 mm (4 inches) below the exothermic connection. Excavated material shall be

removed from the site.

**855.05 Basis of Payment.** This work will be paid for at the contract unit price each for LIGHTING CONTROLLER, of the enclosure and control type indicated.

## SECTION 856. NAVIGATION OBSTRUCTION LIGHTING CONTROLLER

**856.01 Description.** This work shall consist of furnishing and installing an electrical control cabinet with control device(s), distribution equipment, foundation and wiring for control of navigation obstruction lighting.

**856.02 Materials.** Materials shall be according to the following Articles of Section 1000 - Materials:

#### 856.03 Installation.

(a) General. The construction and installation shall be according to N.E.C. Article 373 and the N.E.S.C.

The lighting controller installation shall be according to the details, location, and orientation shown on the plans.

The Contractor shall confirm the orientation of the lighting controller with the Engineer prior to installing the foundation.

All conduit entrances into the lighting controller shall be sealed with a pliable waterproof material.

(b) Controller Mounted on Concrete Foundation. The lighting controller enclosure or pedestal shall be set plumb and level on the foundation. It shall be fastened to the anchor bolts with nuts and washers which shall be hot-dipped galvanized or stainless steel. Foundation mounted lighting controllers shall be caulked at the base with silicone.

Where the controller has a metal bottom plate, the plate shall be sealed as a rodent and dust/moisture barrier.

- (c) Controller Mounted on Pole. Aluminum brackets designed for pole mounting shall be used. Enclosures greater than 650 mm (26 inches) in height shall have stiffener plates on both top and bottom of the rear wall for mounting brackets. All hardware mounting hardware shall be stainless steel.
- **856.04 Basis of Payment.** This work will be paid for at the contract unit price each for NAVIGATION OBSTRUCTION LIGHTING CONTROLLER, of the enclosure and control type indicated.



# **SECTION 857. TRAFFIC ACTUATED CONTROLLER**

- **857.01 Description.** This work shall consist of furnishing and installing a traffic actuated solid state digital controller in the controller cabinet of the type specified with peripheral equipment.
- **857.02 Materials.** Materials shall be according to the following Articles of Section 1000 Materials:

Item Article/	/Section
(a) Traffic Actuated Solid State Digital Controller	1085.45
(b) Controller Cabinet and Peripheral Equipment	1085.47

#### CONSTRUCTION REQUIREMENTS

**857.03 Installation.** The traffic actuated controller shall be installed in a completely wired cabinet, with necessary connections for proper operation. The model and serial number of the controller shall be permanently affixed on the front or top of the controller housing and readily visible.

All conduit entrances into the controller cabinet shall be sealed with a pliable waterproof material. Electrical cables inside the controller cabinet shall be neatly trained along the base and back of the cabinet. Each conductor shall be connected individually to the proper terminal, and the spare conductors shall be insulated and bound into a neat bundle. Each cable shall be marked with identification meeting the approval of the Engineer and recorded on a copy of the plans for the intersection and submitted to the Engineer.

The traffic actuated controller shall provide the NEMA eight phase dual ring operation for the phase designation diagram shown on the plans and the preemption sequence of operation, when shown on the plans. A print out of all controller settings including coordination and preemption shall be provided to the Engineer.

**857.04 Basis of Payment.** This work will be paid for at the contract unit price each for FULL-ACTUATED CONTROLLER AND CABINET of the type specified, which price shall include the conflict monitor, load switches, and flasher relays. The transceiver shall be furnished with the controller only when specified as a separate pay item on the plans.

# **SECTION 858. FLASHER CONTROLLER**

- **858.01 Description.** This work shall consist of furnishing and installing a flasher controller and cabinet.
- **858.02 Materials.** Materials shall be according to the following Articles of Section 1000 Materials:

	Item	Article/Section
(a)	Flasher Controller	

#### Flasher Controller

## CONSTRUCTION REQUIREMENTS

**858.03 Installation.** The flasher controller shall be installed according to the details shown on the plans.

**858.04** Basis of Payment. This work will be paid for at the contract unit price each for FLASHER CONTROLLER.

#### **SECTION 859. TRANSCEIVER**

**859.01 Description.** This work shall consist of furnishing and installing a transceiver with necessary connections for proper operation.

**859.02 Materials.** Materials shall be according to the following Articles of Section 1000 - Materials:

# **CONSTRUCTION REQUIREMENTS**

**859.03 Installation.** The transceiver shall be connected to the communication interface panel. The transceiver shall be assigned a unique address in the master controller.

**859.04** Basis of Payment. This work will be paid for at the contract unit price each for TRANSCEIVER.

The interface panel, all necessary harnesses, and the programming of the controller and the master controller shall be included in this item.

## SECTION 860. MASTER CONTROLLER

860.01 Description. This work shall consist of furnishing and installing a master controller with the necessary connections for proper operation.

**860.02 Materials.** Materials shall be according to the following Articles of Section 1000 - Materials:

# **CONSTRUCTION REQUIREMENTS**

## 860.03 Installation.

- (a) Telephone Service. The Contractor shall arrange with the telephone company to install a standard voice-grade dial-up telephone line. Any charges by the telephone company to provide initial service will be paid for in according to Article 109.05.
- (b) System Set-up. The Contractor shall set up graphic displays and all

software parameters, including compatible viewing and control capabilities from the remote monitor.

- (c) Housing and Cabinet. The model and serial numbers shall be affixed on the front of the housing and shall be readily visible. The master controller shall be installed in the same cabinet with a traffic signal controller. One circuit breaker rated at 10 amperes shall be provided.
- (d) Software. Based on the need up to 3 complete sets of the latest edition of registered remote monitoring software with full manufacturer's support shall be furnished with each master controller. Each set shall consist of complete software on 90 mm (3 1/2 inch) floppy disks, and a bound set of manuals containing loading and operating instructions. The distribution of the software will be directed by the Engineer.
- **860.04 Basis of Payment.** This work will be paid for at the contract unit price each for MASTER CONTROLLER.

## SECTION 861. DIGITAL TIME SWITCH

- **861.01 Description.** This item shall consist of furnishing, installing, and setting a digital time switch, with necessary connections for proper operation.
- **861.02 Materials.** Materials shall be according to the following Articles of Section 1000 Materials:

**861.03** Basis of Payment. This work will be paid for at the contract unit price each for DIGITAL TIME SWITCH.

## **SECTION 862. PEDESTRIAN PUSH-BUTTON**

- **862.01 Description.** This work shall consist of furnishing and installing a pedestrian push-button and an appropriate traffic signal instruction sign.
- **862.02 Materials.** Materials shall be according to the following Articles of Section 1000 Materials:

## CONSTRUCTION REQUIREMENTS

**862.03 Installation.** The pedestrian push-button shall be mounted approximately 1050 mm (42 inches) above the sidewalk level. The mounting saddle shall be completely in contact with the post or pole on which it is mounted. The Contractor shall apply an anti-seize paste compound on all nuts and bolts prior to assembly. The methods of mounting both the pedestrian push-button and the sign shall be approved by the Engineer.

The traffic signal instruction sign applicable to pedestrians shall be according to the National MUTCD, i.e., signs in series R 10-1 through R 10-4.

**862.04** Basis of Payment. This work will be paid for at the contract unit price each for PEDESTRIAN PUSH-BUTTON.

## SECTION 863. CONTROLLER CABINET AND PERIPHERAL EQUIPMENT

- **863.01 Description.** This work shall consist of furnishing and installing a cabinet and peripheral equipment for an existing traffic signal controller.
- **863.02 Materials.** Materials shall be according to the following Articles of Section 1000 Materials:
- **863.03 General.** The cabinet shall be furnished with panel, terminal facilities, conflict monitor, load switches, and flasher relays complete with necessary connections for proper operation. The type of cabinet shall be as specified on the plans.
- **863.04** Basis of Payment. This work will be paid for at the contract unit price each for CONTROLLER CABINET of the type specified.

## SECTION 864. TRANSCEIVER-FIBER OPTIC

- **864.01 Description.** This work shall consist of furnishing and installing a fiber optic transceiver for a traffic signal controller.
- **864.02 General.** The fiber optic transceiver shall be installed according to Section 859 and the following:
- All fiber optic components except the interconnect cable itself, required to provide proper communication between local controllers and/or masters, shall be furnished and installed as part of this item.
- **864.03 Transceiver Components.** The transceiver and all related components and connections shall be provided for the proper operation of the fiber optic interconnect communication system in each traffic signal cabinet. These items shall include but not be limited to the following:
  - (a) Distribution Enclosure. Field cable shall terminate in the controller cabinet within a wall-mount distribution enclosure. The distribution enclosure shall seal out dust and moisture. The size shall be sufficient to store all fiber windings and splices. The location of the distribution enclosure shall not restrict access to other controller components. The field cable shall be firmly secured to the enclosure with hose clamps or similar clamping devices. The cabinet cable shall leave the enclosure through rubber grommets or similar devices to protect the cable against wear. The field

cable jacket shall be removed and all protective gel cleaned from the loose tubes as recommended by the cable supplier. Sufficient lengths of every loose tube shall be coiled within the enclosure to reach the fiber interface panel or modem.

- (b) Connectors. Only ST type connectors of ceramic ferrule and Physical Contact (PC) end finish shall be used to terminate fibers to equipment. ST or mechanical connectors shall not be used to splice cables.
- (c) Splices. The fiber cable shall be installed in continuous runs between controller cabinets or as marked on the plans. No splices will be allowed outside the controller cabinets. Only mechanical or fusion splices will be allowed in the controller cabinet. The splices shall be secured in a splice organizer tray.
- (d) Modems and Power Source. Communication between local controllers and the system master controllers shall be facilitated by the use of fiber optic modems. The modems shall be capable of communications with NEMA traffic signal controllers in a coordinated closed loop system. Modems shall be active devices providing full-duplex communication via RS-232 connector and supporting daisy-chain wiring. The nominal operating wavelength shall be 850 nm. The modems shall be according to NEMA Standards for Traffic Control Systems, TS1, Section 2. A minimum of 2 fiber optic ports shall be provided on each modem. Each fiber optic port shall be ST-PC style and shall be identified as either transmitter or receptor of the optic signal. The other end of the modem shall have the male type RS-232 connector. The modems shall be installed on the interface panel on the side of the controller cabinet. The modems shall be powered from the controller telemetry module.
- (e) Light Source. A LED light source with a wavelength that is the system wavelength shall be used. The LED shall be stable within 0.1 dB in intensity over a time period sufficiently long to perform the measurement. The output of the LED shall overfill the input end of the launch fiber in both numerical aperture (NA) and core diameter.
- (f) Power Meter. The detector in the power meter shall have an effective NA and active region that is larger than the receive reference cable and/or the fiber under test. The power meter shall have a minimum range from +3 dBm to -40 dBm. The power meter shall have an accuracy of  $\pm$  0.5 dB through the operating temperature and minimum resolution of 0.1 dB.
- (g) Breakout Kits. Breakout kits shall provide for the separation and protection of individual fibers with buffer tubing and jacketing materials suitable for termination of the fiber with the fiber optic connectors as specified.
- (h) Interface Panel. This panel interfaces the controller telemetry to the fiber optic modems and provides terminal block tie points for the other telemetry signals. A terminal for each conductor in the cable shall be required.
- **864.04** Testing and Product Information. Field testing of the equipment shall be according to Article 801.14(b). All components of the fiber optic system shall have the manufacturer's name, address, type, style, model or serial number, and catalog number on a plate secured to the equipment. It is advised that the system be of the

same manufacture to assure uniformity, interchangeability of components, single responsibility, and most satisfactory service.

**864.05** Basis of Payment. This work will be paid for at the contract unit price each for TRANSCEIVER - FIBER OPTIC, for each traffic signal cabinet.

#### SECTION 865. BREAKAWAY DEVICES

**865.01 Description.** This item shall consist of furnishing and installing a breakaway device, on a pole foundation.

**865.02 Materials.** Materials shall be according to the following Articles of Section 1000 - Materials:

	Item	e/Section
(a)	<b>Breakaway Devices</b>	 1085.36

#### 865.03 Installation.

- (a) Transformer Base. The transformer base shall be installed level and flush with the foundation without the use washers or shims according to the manufacturer's installation procedures.
- (b) Breakaway Couplings. The breakaway couplings shall be coordinated to match anchor bolt size. The breakaway coupling shall be installed on the anchor bolts, 3.2 mm to 9.5 mm (1/8 to 3/8-inch) above the top of the foundation according to the manufacturer's recommendations. The coupling installation shall not be used to level the pole base in lieu of a level foundation.



**865.04** Basis of Payment. This item will be paid at the contract unit price each for BREAKAWAY DEVICE, TRANSFORMER BASE, of the bolt circle indicated; BREAKAWAY DEVICE, COUPLING, WITH ALUMINUM SKIRT, or WITH FIBERGLASS SHROUD.

The foundation will be paid for separately according to Section 838.



## SECTION 866. HIGHWAY LIGHTING ELECTRIC SERVICE INSTALLATION

**866.01 Description.** This work shall consist of all material and labor required to extend, connect, or modify the electric services.

## CONSTRUCTION REQUIREMENTS

**866.02 Coordination.** The Contractor shall contact and coordinate both the work required and the timing of the installation fully with the electric utility.

In the event of delay by the utility, no extension of time will be considered applicable for the delay unless the Contractor can produce written evidence of a request for electric service within 30 days of contract execution.

- **866.03 Installation.** The Contractor shall ascertain the work being provided by the electric utility and shall provide all additional material and work required to complete the electric service work in complete compliance with the requirements of the utility.
- **866.04** Basis of Payment. This work will be paid for at the contract unit price each for ELECTRIC SERVICE INSTALLATION which shall be payment in full for the work.

Any charges by the utility company to provide electrical service to the service installation will be paid for according to 109.05.

No additional compensation will be allowed for work required for the electric service, even though not explicitly specified.

#### SECTION 867. TRAFFIC SIGNAL ELECTRICAL SERVICE INSTALLATION

**867.01 Description.** This work shall consist of furnishing and installing an electrical service installation.

Type A service installation shall include one weather-head, one ground rod, one meter pan, one circuit breaker, one weatherproof enclosure, galvanized steel conduit, nonmetallic conduit, conduit clamps, lag screws, electric cables of the type and size specified by local utility company, and other miscellaneous items. The meter will be furnished by the utility company.

Type B service installation shall conform to the Type A service installation, except no meter will be installed.

Type C service installation shall include one weatherproof enclosure, one circuit breaker, one weather-head, one ground rod, galvanized steel conduit, conduit clamps, lag screws, electric cables of the type and size specified by a local utility company, and other miscellaneous items. The Contractor shall make connections to the line side of the circuit breaker, and coil the remainder above the junction box for installation by the utility company. No separate grounding of weatherproof enclosure will be installed, unless it is required by the utility company.

- **867.02** Materials. Materials shall meet the requirements of Article 1085.58.
- **867.03** Installation. The service installation shall be installed according to the details shown on the plans. Exceptions will be made to comply with the local utility company's standard practices.
- **867.04 Basis of Payment.** This work will be paid for at the contract unit price each for SERVICE INSTALLATION of the type specified, which price shall be payment in full for furnishing and installing the service installation complete. Any charges by the utility company to provide electrical service to the service installation will be paid for according to Article 109.05.

## SECTION 868. TRENCH AND BACKFILL FOR ELECTRICAL WORK

**868.01 Description.** This work shall consist of constructing and backfilling a trench for the accommodation of cables and raceways.

**868.02 Materials.** Materials shall be according to the following Articles of Section 1000 - Materials:

## CONSTRUCTION REQUIREMENTS

## 868.03 General.

(a) Trench. Trenches shall have a minimum depth of 750 mm (2.5 ft.) or 600 mm (2.5 ft.) as indicated on the plans, and shall not exceed 300 mm (12 inches) in width without prior approval of the Engineer. The trenches shall be constructed to permit easy installation of cable or unit duct without twisting kinks, or sharp bends. Where conduit enters the trench, the bottom of the trench shall be built up to at least half the diameter of the conduit opening so the emerging unit duct or cable will have a smooth bed.

If the trench depth is less than 300 mm (12 inches) because of rock or concrete, the Contractor shall cut a groove in the obstructing material so the trench is 300 mm (12 inches) deep. The unit duct shall be laid in this groove and covered to grade with Class SI Concrete.

Where the trench depth exceeds 300 mm (12 inches), but less than 600 mm (24 inches), the bottom shall be made smooth and free of short radius dips by filling low sections with trench backfill.

Where separate circuit runs are to be installed parallel with each other, one common trench shall be used. At the locations where a trench crosses other existing cable systems, the trench shall be hand dug 2 m (6.5 ft.) to either side of the crossing.

The Contractor shall be responsible for damage incurred in any area of the project such as medians, pavement, shoulders, backslopes, driveways, and sidewalks and shall restore them to their original condition as directed by the Engineer.

(b) Plowed Installation. Except where trenching is specifically indicated on the contract drawings, the Contractor shall have the option to plow unit duct or coilable nonmetallic conduit into place in lieu of trench and backfill.

Where coil raceway or cable is plowed-in, it shall be done by lay-in plow-feeding of the unit duct. Bullet-nose tunnel pulling of the polyethylene duct with a plow will not be allowed.

The coil, raceway, or cable shall be round and free of kinks when fed into the plow. Before final wire and cable connections are made, the Contractor shall demonstrate to the satisfaction of the Engineer, that all conductors within the duct are free to move.

Plowing which places all duct, cable and conductors of a circuit in a single cavity so they are not twisted, kinked, or damaged and are the specified distance below grade will be accepted as trench and backfill. Where another circuit is plowed in parallel to the first, the distance between the two shall be not less than 300 mm (12 inches) nor more than 600 mm (24 inches).

- (c) Backfill. Backfill shall be deposited in uniform layers not exceeding 150 mm (6 inch) thick loose measure. The material in each layer shall be mechanically compacted by tamping with power tools approved by the Engineer in such a manner as not to disturb, kink, or crush the cables, conductor, duct or conduit.
- (d) Cable Marking Tape. Underground cable marking tape shall be installed 300 mm (12 inches) below finished grade for all underground cable and raceway runs. Splicing of the underground cable marking tape shall be accomplished with metal clips to maintain electrical continuity along the entire length of the tape. In addition to metal clips, all splices must be wrapped with a waterproof adhesive tape to prevent corrosion of the metal core.

## 868.04 Method of Measurement.

- (a) Contract Quantities. The requirements for the use of contract quantities shall be according to Article 202.07 (a).
- (b) Measured Quantities. This work will be measured in meters (feet) along the centerline of the trench. Trench and backfill will not be measured for payment for conduit which is pushed. Where separate circuit runs are placed in a common trench, only one run will be measured for payment along the centerline of the parallel portion.

**868.05** Basis of Payment. This work will be paid for at the contract unit price per meter (foot) for TRENCH AND BACKFILL FOR ELECTRICAL WORK, of the depth specified.

Excavation in rock will be classified and paid for as specified in Section 502.

## REMOVAL AND RELOCATION

# **SECTION 870. TEMPORARY LIGHTING REMOVAL**

**870.01 Description.** This item shall consist of the disconnection and removal of the temporary lighting system.

**870.02 Removal.** Removal shall include the removal of temporary poles (which may be either wood, concrete, steel, or aluminum), aerial cable and all associated apparatus, and connections. This removal shall include removal of all wiring and connections to the associated lighting controller. All equipment and material except for luminaires removed as part of this item shall become property of the Contractor and shall be removed from the site.

All luminaires shall be inspected by the Engineer. Non-operating or damaged luminaires shall be fixed or replaced in kind by the Contractor.

Luminaires shall be removed, boxed in new containers approved by the Engineer and delivered and unloaded at a storage facility of the Owner, as designated by the Engineer.

Pole holes shall be backfilled according to Section 868.

With the approval of the Engineer, the Contractor may partially remove the temporary lighting system after parts of the permanent lighting system are operational. Any modifications to the temporary system to keep the temporary lighting system and permanent lighting system operational shall be at the Contractor's own expense.

- **870.03 Method of Measurement.** Units measured for payment shall be counted on a per-pole basis, regardless of pole material, mounting height, the number and type of mast arm(s), luminaires and other appurtenant items attached thereto.
- **870.04** Basis of Payment. This work will be paid for at the contract unit price each for REMOVAL OF TEMPORARY LIGHTING UNIT.

#### SECTION 871. REMOVAL OF LIGHTING FIXTURES

**871.01 Description.** This work shall consist of the removal and disposal of existing light pole foundations, lighting units, and luminaires, and shall also include the backfilling of the excavated areas.

## CONSTRUCTION REQUIREMENTS

**871.02 General.** Any damage resulting from the removal and/or transportation of the lighting fixtures and associated hardware, shall be repaired or replaced in kind, at the Contractor's expense, to the satisfaction of the Engineer. The Engineer will be the sole judge to determine the extent of damage and the suitability of repair and/or replacement.

No removal work shall be permitted without approval from the Engineer. When the underground electric cables shall be abandoned, 300 mm (1 ft.) below ground level shall be cut. Cables in unit duct may be removed from the duct and may

become property of the Contractor. Duct shall be abandoned and cut 300 mm (1 ft.) below ground level.

Any pole removal shall start as soon as the temporary lighting or permanent lighting, as applicable, is placed in approved operation. An inspection and approval by the Engineer will take place before any associated proposed permanent or temporary lighting is approved for operation.

When certain poles are mounted on transformer bases, removal shall be at no additional compensation.

Luminaires shall be removed, boxed in new containers approved by the Engineer and delivered and unloaded at a storage facility of the owner, as designated by the Engineer.

- **871.03** Removal of Lighting Fixtures, No Salvage. When indicated, poles, mast arms, luminaires, and all associated hardware and appurtenances shall become the property of the Contractor and shall be disposed of off the project site.
- **871.04** Removal of Lighting, Owner Salvage. When indicated, poles, mast arms, luminaires, and all associated hardware and appurtenances shall remain the property of the Owner and shall be delivered to an Owner's facility within the District and unloaded and stacked there, as directed by the Engineer. Wood blocking, banding or other appurtenant items required for proper stacking shall be included.
- **871.05** Removal of Lighting Foundations. Concrete foundations shall be removed to at least 600 mm (2 ft.) below grade with removed material disposed of off the site. The removal shall extend deeper where required to facilitate roadway construction at no additional cost. Underground conduits and cables shall be separated from the foundation at 760 mm (2.5 ft.) below grade and shall be abandoned or re-used as indicated.

Where light poles are removed from retaining or parapet walls, the Contractor shall cut off the anchor bolts and conduit stub-ups 25 mm (1 inch) below the wall surface and fill all voids with portland cement concrete mortar with curing compound making a smooth surface to match the shape of the wall.

Existing steel helix foundations shall be removed and cleaned to expose the foundation for inspection by the Engineer. Those foundations deemed not re-usable by the Engineer shall become the property of the Contractor and shall be disposed of off the right of way. Those foundations deemed re-usable by the Engineer shall be delivered to an Owner's storage facility and unloaded and stacked there as directed by the Engineer.

The void caused by the removal of the foundations shall be backfilled with trench backfill according to Section 868.

**871.06** Removal of Underpass Luminaire. When directed by the Engineer the entire underpass lighting system shall be removed. Removal of the associated conduit, wire, and junction boxes shall be included in the cost of this item.

Where indicated on the plans removal of existing electrical connections to bridge mounted overhead signs shall be included.

**871.07 Method of Measurement.** Each lighting unit (pole, mast arm, luminaire, and appurtenant equipment) which is removed and delivered to the Owner's storage or disposed of as indicated, shall be counted as a unit for payment.

Removal of the existing underpass lighting shall be measured by the unit price per each underpass luminaire removed.

Foundation removal shall be measured as each.

**871.08** Basis of Payment. This work will be paid for at the contract unit price each for REMOVAL OF EXISTING LIGHTING UNIT, SALVAGE; or REMOVAL OF EXISTING LIGHTING UNIT, NO SALVAGE; LIGHTING FOUNDATION REMOVAL of the type specified.

## **SECTION 872. RELOCATE LIGHTING UNITS AND POLES**

- **872.01 Description.** This item shall consist of removing an existing lighting unit and reinstalling temporary poles and/or lighting unit on a proposed foundation in locations as designated by the Engineer.
- **872.02 Materials.** Materials shall be according to the following Articles of Section 1000 Materials:

## CONSTRUCTION REQUIREMENTS

# 872.03 Lighting Unit.

(a) Removal. The existing lighting unit shall be disconnected and removed from the existing foundation by removing the anchor bolt nuts and lifting the lighting unit from the foundation.

Any damage sustained to the lighting unit during removal operations shall be repaired, or replaced in kind, to the satisfaction of the Engineer at the Contractor's expense.

(b) Reinstallation. The lighting unit shall be installed immediately on the proposed foundation. The electric cables shall be connected to power supply cables so the reinstalled lighting unit becomes operational the same evening without interruption. Temporary wiring will be permitted at the discretion of the Engineer.

When a conduit or duct extension is required, the conduit and/or duct maybe spliced and a new span of cable shall be installed. The Engineer will inspect all conduit and/or duct splices before backfilling.

The existing pole wire shall be preserved and reconnected to the proposed underground wiring.

The anchor bolt and handhole covers of the lighting unit shall be removed and reinstalled. If during removal, the screws holding the cover break, a hole in the pole base shall be drilled and threaded to accept a new screw. The new screw shall be a nylon screw with a metal core.

The mast arm and/or luminaire may be removed and reinstalled as a unit, at the option of the Contractor, with the approval of the Engineer. No additional compensation will be paid for these operations.

**872.04 Light Towers.** The space between the finished top of the foundation and the bottom of the base plate of the pole shall be enclosed with an expanded metal screen made of stainless steel. The mesh of the screen shall be 6 mm (1/4 inch) or less as approved by the Engineer. The screen shall be held in place with bands made of stainless steel. The ends shall be held tight by a ratchet-type device. Grouting shall not be used to enclose the above described space.

The light pole shall be straight and centered on its longitudinal axis, under no-wind conditions, so, when examined with a transit from any direction, the deviation from the normal shall not exceed 3 mm (1/8 inch) within any 1.5 m (5 ft.) of height, with total deviation not to exceed 75 mm (3 inches) from the vertical axis through the center of the pole base.

# 872.05 Temporary Wood Poles.

- (a) Removal and Reinstallation. The temporary light unit shall be installed immediately at the new location. The electric cables shall be connected to power supply cables so the reinstalled temporary light unit becomes operational the same evening without interruption. If the existing electric cables are not of sufficient length to make the new connection, a new continuous span of electric cables, of equal or better quality, shall be installed at no additional cost.
  - Any damage sustained to the temporary light unit during removal operations shall be repaired, or replaced in kind, to the satisfaction of the Engineer at the Contractor's expense.
- (b) Luminaire Circuit Identification. Each pole which is to be relocated shall be checked during the Preconstruction Inspection for complete circuit identification and corrected as stated in Article 1085.05.

Any damage to the identification occurring prior to final acceptance shall be repaired or replaced according to the specifications as no additional cost to the State.

**872.06 Method of Measurement.** When a temporary lighting unit or pole is in conflict with the proposed construction, then the Engineer will authorize the Contractor to relocate the temporary lighting unit and be paid for the relocation.

When a temporary lighting unit or pole is not in conflict with the proposed construction, but is in conflict with the Contractor's proposed sequence of operations, or the relocation is for the Contractor's convenience, relocation of said temporary lighting unit will be at the Contractor's option and expense. The Contractor shall obtain the Engineer's approval before any pole or unit is relocated.

If the Engineer determines a given temporary lighting unit's pole setting has deteriorated to such an extent that the pole poses a safety hazard, the temporary

lighting unit may be reset in or near the same location. Resetting of the pole will not be paid for if the pole setting has been weakened by construction operations. Resetting of the pole will be paid for if the setting has been weakened due to natural occurrences, (i.e. rain storms). In all cases the Engineer will determine if the relocation is or is not at Contractor's expense.

**872.07 Basis of Payment.** This work will be paid for at the contract unit price each for RELOCATE EXISTING LIGHTING UNIT of the type indicated; or RELOCATE EXISTING LIGHT TOWER or RELOCATE EXISTING TEMPORARY POLES; which shall be payment in full for performing the work.

# SECTION 873. REMOVAL, RELOCATION, AND REBUILDING OF EXISTING SIGNAL AND APPURTENANCES

**873.01 Description.** This work shall consist of the removal, removal and relocation, and or the rebuilding of existing signal items and appurtenances in the construction of signalized intersections.

#### CONSTRUCTION REQUIREMENTS

**873.02 Relocation.** All existing signal items shall be removed and relocated as shown on the plans. The installation shall be done according to the specifications for the specific item. Any damage done to the existing signal items or appurtenances shall be repaired or replaced by the Contractor at his/her own expense, as directed by the Engineer.

Relocation of the existing traffic signal controller and its associated equipment shall also consist of reusing the controller cabinet. Anchor bolts, nuts, and washers shall be new for the installation of an existing traffic controller. The controller shall be installed according to Article 857.03.

Relocation of an existing signal head shall consist of removing an existing signal head, optically programmed signal head, or combination signal head and installing it according to Article 840.02.

Installation of the pedestrian signal head shall be according to Article 848.01.

Installation of an existing illuminated sign shall be according to Article 848.01.

Relocation of an existing signal post, controller cabinet, or mast arm assembly and pole shall include the removal and installation on a new concrete foundation with new anchor bolts, nuts, and washers, according to Article 838.03.

When removing an existing pedestrian push-button, the related sign shall be removed and installed at the new location. The push-button will be installed according to Article 862.03.

This work shall consist of rebuilding the components of one or more existing signal heads into a required type signal head as noted on the plans, which may require removing old components and/or adding new components.

**873.03 Rebuilding Signal Head.** The existing signal components shall be removed and altered by adding or removing signal faces and/or mounting hardware. The additional signal faces and/or sections shall be of the same type and make as

the existing signals. All lenses and reflectors shall be cleaned, and the reassembled signal head shall be cleaned and repainted. Rebuilding an existing signal head may require removing old components and/or adding new components. All components removed from the existing signal head and not reused shall be disposed of as directed by the Engineer. The Contractor may, without additional compensation, furnish all new components, in lieu of rebuilding. Installation shall be according to Article 840.02.

**873.04 Modifying Existing Controller.** This work shall consist of modifying an existing controller to change the existing sequence of operation to the proposed sequence of operation. Both the existing and the proposed sequence of operation will be shown on the plans. Upon completion, the Contractor shall furnish the Engineer five copies of the cabinet wiring diagram.

#### 873.05 Removal.

- (a) Existing Traffic Signal Equipment. The existing traffic signal equipment at an intersection shall be removed and disposed of as listed on the plans and as directed by the Engineer. The Contractor shall be responsible for repairing or replacing any items of equipment damaged during the process to the satisfaction of the Engineer.
  - All equipment shall be stored off the job site at an approved location, and electrical components shall be stored indoors.
- (b) Handhole. The frame and cover of an existing handhole shall be broken off the top section the handhole wall to a minimum depth of 900 mm (3 ft.) below the surrounding grade, or as specified, backfilled with approved material, and the surface reconstructed to match the adjoining area. The concrete debris shall be disposed of outside the right of way, and the frame and cover disposed of as directed by the Engineer. If the handhole is located in the sidewalk area, the entire sidewalk square or squares where the handhole is located shall be replaced with new sidewalk.
- (c) Concrete Foundation. The concrete foundation shall be removed to a level at least 900 mm (3 ft.) below the adjacent grade, backfilled with approved material, and the surface reconstructed to match the adjoining area. The foundation shall be disposed of outside the right of way. If the concrete foundation is located in the sidewalk area, the entire sidewalk square or squares where the concrete foundation is located shall be replaced with new sidewalk.
- (d) Electric Cable from Conduit. An existing electric cable shall be removed, as directed by the Engineer, from a conduit.
- **873.06** Removal and Reinstallation. This work shall consist of removing an existing electric cable from a conduit and then reinstalling it in an existing or a new conduit. The conduit shall be cleaned and swabbed prior to reinstallation of cable.
- **873.07 Method of Measurement.** Removal and removal and reinstallation of existing electric cable will be measured for payment in place in meters (feet). If two or more cables in a conduit are to be removed or removed and reinstalled, each cable will be measured for payment separately.

Removal, Relocation, and Rebuilding of Existing Signal and Appurtenances

Art. 873.08

**873.08** Basis of Payment. Removal and Relocation will be paid for at the contract unit price each for RELOCATE EXISTING SIGNAL HEAD, RELOCATE EXISTING PEDESTRIAN SIGNAL HEAD, RELOCATE EXISTING ILLUMINATED SIGN, and RELOCATE EXISTING PEDESTRIAN PUSH-BUTTON.

Removal and reinstallation of existing traffic signal items will be paid for at the contract unit price each for RELOCATE EXISTING TRAFFIC SIGNAL CONTROLLER, RELOCATE EXISTING TRAFFIC SIGNAL POST, or RELOCATE EXISTING MAST ARM ASSEMBLY AND POLE.

Concrete foundations, when specified, will be measured and paid for according to Section 838.

Rebuilding and existing signal head will be paid for at the contract unit price each for REBUILD EXISTING SIGNAL HEAD.

Modifying an existing controller will be paid for at the contract unit price each for MODIFY EXISTING CONTROLLER. Some of the parts and equipment required for the completion of this work may be listed on the plans as separate pay items. All other necessary parts, labor, and equipment required will be included in the cost of modifying the controller.

Removal of an existing electric cable will be paid for at the contract unit price per meter (foot) for REMOVE ELECTRIC CABLE FROM CONDUIT.

Removing and reinstalling the electric cable will be paid for at the contract unit price per meter (foot) for REMOVE AND REINSTALL ELECTRIC CABLE FROM CONDUIT.



#### **SECTION 1000. MATERIALS**

#### GENERAL

#### SECTION 1001. PORTLAND CEMENT OR BLENDED HYDRAULIC CEMENT

**1001.01 Specifications.** Portland cement, portland-pozzolan cement and portland blast-furnace slag cement shall be according to ASTM specifications and meet the standard physical and chemical requirements. The Engineer may specify optional physical and chemical requirements. ASTM sampling and test procedures will be used to verify the requirements in ASTM specifications. Specific references to the types of cement are as follows:

Specifications for:	<u>Type</u>	<u>ASTM</u>
Portland Cement <sup>1</sup>	I, II, III, IV, V, IA, IIA, IIIA	C 150
Portland-Pozzolan Cement <sup>2</sup>	IP, I(PM), IP(MS) IP-A, I(PM)-A, IP-A(MS)	C 595
Portland Blast-Furnace Slag Cement <sup>3</sup>	IS, I(SM), IS(MS), IS-A, I(SM)-A, IS-A(MS)	C 595

- 1/ Type I portland cement may be used at the option of the Contractor. Type IA, II, IIA, III, IIIA, IV, and V portland cement may be used when specified or when approved in writing by the Engineer.
- 2/ Type IP portland-pozzolan cement or Type I(PM) pozzolan-modified portland cement may be used at the option of the Contractor provided the pozzolan constituent does not exceed 21 percent of the mass (weight) of the portland-pozzolan cement. Type IP-A, I(PM)-A, IP(MS), and IP-A(MS) portland-pozzolan cement may be used when specified or when approved in writing by the Engineer. Portland-pozzolan cements shall not be used after October 15 nor before April 1.
- 3/ Type IS portland blast-furnace slag cement or Type I(SM) slag-modified portland cement may be used at the option of the Contractor provided the slag constituent does not exceed 25 percent of the mass (weight) of the portland blast-furnace slag cement. Type IS-A, I(SM)-A, IS(MS), and IS-A(MS) portland blast-furnace slag cement may be used when specified or when approved in writing by the Engineer. Portland blast-furnace slag cements shall not be used after October 15 nor before April 1.
- **1001.02 Mixture Designs.** Cement factors of mixes containing portland-pozzolan cement or portland blast-furnace slag cement may be adjusted by the Engineer to meet the mix design strength requirement of Article 1020.04.
- **1001.03 Uniformity of Color.** Cement contained in single loads or in shipments of several loads to the same project shall be uniform in color. Visible differences in the color shall be cause for rejection.

- 1001.04 Mixing Brands and Types. Different brands or different types of cement from the same manufacturing plant, or the same brand or type from different plants shall not be mixed or used alternately in the same item of construction unless approved by the Engineer.
- 1001.05 Storage. Cement shall be suitably stored and protected against dampness. Cement which has partially set or contains hardened lumps will be rejected. Different brands or different types of cement from the same manufacturing plant, or the same brand or type from different plants shall be kept separate.
- 1001.06 Sampling and Testing. The Department may sample and test cement at the manufacturing plant or one of its terminals. Provisions of Article 106.04 shall apply, except an approved sampling location and the necessary personnel to assist the Department representative in obtaining samples shall be provided.

The Department may sample and test cement at the final destination. An approved sampling location and the necessary personnel to assist the Department representative in obtaining samples shall be provided by the Contractor, or the Concrete Producer with whom the Contractor has contracted materials.



The Engineer will permit the use of the cement provided the bill of lading indicates a manufacturing plant which is on the Department's Policy Memorandum, "Portland or Blended Cement Acceptance Procedure For Qualified Plants." If the cement is not from a qualified plant, the Engineer will permit the use of the cement provided the bill of lading states the manufacturer of the cement, and the bill of lading states the cement was tested and approved by the Department.

#### **SECTION 1002. WATER**

- **1002.01** Quality. Water used with cement in concrete, mortar, and water used for curing concrete shall be clean, clear, free from sugar and shall not contain acid, alkali, salts or organic matter in excess of the following amounts when tested according to AASHTO T 26:
  - (a) Acidity and Alkalinity
    - (1) Acidity--0.1 Normal NaOH 2 ml max.\*
    - Alkalinity--0.1 Normal HCI 10 ml max.\*
      - \*To neutralize 200 ml sample.
  - (b) Total Solids

(1)	Organic	0.02% max.
(2)	Inorganic	0.30% max.

- (3)
- (4) Alkali chloride as sodium chloride (NaCl) ...... 0.10% max.

When test data on standard cement specimens made with cement, sand and water from the sample are compared with data obtained on specimens made with the same cement and sand and distilled water, there shall be no indication of unsoundness, marked change in time of set, or variation of more than 10 percent in strength.

**1002.02** Approval of Source. Water which has been approved by the Illinois Department of Public Health for drinking or ordinary household use may be accepted Water Art. 1002.02

without being tested. All other sources must be approved by the Engineer.

The Contractor shall not use water from shallow, muddy or marshy surfaces. The intake of the pipe line shall be enclosed to exclude silt, mud, grass and other solid materials, and there shall be a minimum depth of 600 mm (2 ft.) of water below the intake at all times.

#### **SECTION 1003. FINE AGGREGATES**

**1003.01 Materials.** The aggregate materials shall conform to the following requirements:

(a) Description. The natural and manufactured materials used as fine aggregate are defined as follows:

Sand. Sand shall be the fine granular material resulting from the natural disintegration of rock. Sand produced from deposits simultaneously with and by the same operations as gravel coarse aggregate may contain crushed particles in the quantity resulting normally from the crushing and screening of oversize particles.

Silica Sand. Silica sand shall be composed of not less than 99.5 percent silica (Si0<sub>2</sub>).

Stone Sand. Stone sand shall be produced by washing or processing by air separation the fine material resulting from crushing rock quarried from undisturbed, consolidated deposits or crushing gravel.

Screenings. Screenings shall be the fine material resulting from crushing rock quarried from undisturbed, consolidated deposits or from crushing gravel.

Chats. Chats shall be the tailings resulting from the separation of metals from rocks in which they occur.

Wet Bottom Boiler Slag. Wet bottom boiler slag shall be the hard, angular by-product of the combustion of coal in wet bottom boilers.

Slag Sand. Slag sand shall be the graded product resulting from the screening of air cooled blast furnace slag. Air cooled blast furnace slag shall be the nonmetallic product, consisting essentially of silicates and alumino-silicates of lime and other bases, which is developed in a molten condition simultaneously with iron in a blast furnace.

Granulated Slag Sand. Granulated slag sand shall be the graded product resulting from the screening of granulated slag. Granulated slag shall be the nonmetalic product, consisting essentially of silicates and alumino-silicates of lime and other bases, which is developed in a molten condition simultaneously with iron in a blast furnace. Granulated slag sand is formed by introducing a large volume of water under high pressure into the molten slag.

Steel Slag Sand. Steel slag sand shall be the graded product resulting from the screening of crushed steel slag. Crushed steel slag shall be the nonmetallic product which is developed in a molten condition simultaneously with steel in an open hearth, basic oxygen or electric furnace.

Crushed Concrete Sand. Crushed concrete sand shall be the angular fragments resulting from crushing portland cement concrete by mechanical means.

Construction and Demolition Debris Sand. Construction and demolition debris sand shall be the angular fragments resulting from mechanical crushing/screening of unpainted exterior brick, mortar, and/or concrete with small amounts of other materials. Construction and demolition debris sand shall meet all the requirements of the current Bureau of Materials and Physical Research policy memorandum.

(b) Quality. The fine aggregate shall be from an approved source and shall meet the quality standards listed in the following table and will be accepted on the basis of these tests unless unfavorable conditions showing up in usage indicate the material is unsatisfactory. Except for the minus 75  $\mu m$  (No. 200) sieve material, all fine aggregate shall meet specified quality requirements before being proportioned for mix or combined to adjust gradation. The blended materials shall meet the minus 75  $\mu m$  (No. 200) sieve requirements.

At the time of its use, the fine aggregate shall be free from frozen material and all foreign materials which may have become mixed with it during transportation and handling. Cars used for shipping fine aggregate shall not be caulked with straw, excelsior or similar materials.

FINE AGGREGATE QUALITY						
		CLASS				
QUALITY TEST	Α	В	С			
Na <sub>2</sub> SO <sub>4</sub> Soundness 5 Cycle, AASHTO T 104 <sup>1/</sup> Max. % Loss Minus 75 μm (No. 200) Sieve Mat'l. AASHTO T 11 Max. % <sup>5/</sup> Organic Impurities Check - AASHTO T 21 Deleterious Mat'ls. <sup>4/</sup> Shale Max. %  - Clay Lumps Max. %  - Coal, Lignite & Shells Max. %  - Conglomerate Max. %  - Other Deleterious Max. %  - Total Deleterious Max. %	10 3 Yes <sup>3/</sup> 3.0 1.0 1.0 3.0 3.0 3.0	15 6 <sup>2</sup> /  3.0 3.0 3.0 3.0 3.0 5.0	20 10 <sup>2</sup> / 			

- 1/ As modified by the Department.
- 2/ Does not apply to Gradations FA 20 or 21.
- 3/ Applies only to Sand. Sand exceeding the colorimetric test standard of 11 (AASHTO T 21) will be checked for mortar making properties according to the Illinois Modified AASHTO T 71, and shall develop a compressive strength at the age of 14 days when using Type I or II Cement of not less than 95 percent of the comparable standard.
- 4/ Applies only to sand.
- 5/ Fine aggregate used for bituminous mixtures shall not contain more than 3 percent clay (  $50~\mu m$  (2 micron) or smaller) particles as determined by the Department.
- (c) Gradation. The fine aggregate shall be uniformly graded from coarse to fine, and when tested by means of laboratory sieves (square openings), the aggregate shall conform to the designated gradation.

The gradations prescribed may be manufactured by any suitable commercial process and by the use of any sizes or shapes of plant screen openings necessary to produce the sizes within the limits of the sieve analysis specified.

The gradation numbers and corresponding gradation limits are listed in the following table and represent the limits which will determine suitability for use from all approved sources of supply. The gradation of the material from any one source shall be reasonably uniform and shall not be subject to the extreme percentages of gradation represented by the tolerance limits of the various sieve sizes.

FA 21<sup>3/4/</sup>

100

97±3

80±20

# Fine Aggregates



#### FINE AGGREGATE GRADATIONS SIEVE SIZE Percent Passing Grad 9.5 4.75 2.36 2.00 1.18 425 300 180 150 75 $\mu m^{1/}$ No. mm mm mm mm mm μm μm $\mu m$ μm FA 1 100 97±3 65±20 16±13 5±5 FA 2 100 65±20 20±10 5±5 97±3 FA 3 100 97±3 80±15 50±20 25±15 3±3 FA 4 100 5±5 FA 5 100 92±8 20±20 15±15 FA 6 92±82/ 20±20 6±6 97±3 FA 7 100 75±15 35±10 3+3 FA 8 100 60±20 3±3 2±2 100 FA 9 30±15 5±5 FA 10 100 90±10 60±30 7±7 FA 20<sup>3/</sup> 100 97±3 80±20 50±15 19±11 10±7 4±4

57±18

30±10

20±10

9±9

	FINE AGGREGATE GRADATIONS SIEVE SIZE (ENGLISH UNITS)  Percent Passing									
		<b>I</b>	ı		Percen	t Passing	) 	I	ı	
Grad No.	3/8	No. 4	No. 8	No. 10	No. 16	No. 40	No. 50	No. 80	No. 100	No. 200 <sup>1/</sup>
FA 1 FA 2 FA 3 FA 4 FA 5 FA 6 FA 7 FA 8 FA 9 FA 10 FA 20 <sup>3/</sup> FA 21 <sup>3/4/</sup>	100 100 100 100 100 100	97±3 97±3 97±3 92±8 92±8 <sup>2</sup> / 100 97±3 97±3	100 100 80±20 80±20	80±15 97±3 100	65±20 65±20 5±5 50±15 57±18	50±20 75±15 60±20 90±10	16±13 20±10 30±15 19±11 30±10	25±15 35±10 60±30	5±5 5±5 20±20 20±20 3±3 5±5 10±7 20±10	3±3 15±15 6±6 3±3 2±2 7±7 4±4 9±9

<sup>1/</sup> Subject to maximum percent allowed in Fine Aggregate Quality Table.

- 2/ 100 percent shall pass the 25-mm (1-inch) sieve except that for bedding material 100 percent shall pass the 9.5-mm (3/8-inch) sieve. If 100 percent passes the 12.5-mm (1/2-inch) sieve, the 4.75 mm (No. 4) sieve may be 75 ± 25.
- 3/ Acceptance of FA 20 and FA 21 shall be based on the current Bureau of Materials and Physical Research Policy Memorandum.
- 4/ For Class I, Type 2. When used, either singly or in combination with other sands, the amount of material passing the 75  $\mu$ m (No. 200) sieve (washed basis) in the total sand fraction for mix design shall not exceed 10 percent.
- (d) Incompatibility. Incompatibility of any of the gradations or combinations of gradations permitted resulting in unworkable mixtures, nonadherence to the final mix gradation limits, or any other indication of incompatibility shall be just cause for rejection of one or both of the sizes.
- (e) Storage of Fine Aggregate. Sites for storage of all fine aggregates shall be grubbed and cleaned prior to storing the material. Stockpiles shall be built in such a manner as to prevent segregation and to ensure reasonably uniform gradation throughout the stockpile. Stockpiles shall be separated to prevent intermingling at the base. If partitions are used, they shall be of sufficient heights to prevent intermingling. Fine aggregates for portland cement concrete and bituminous mixtures shall be handled in and out of the stockpiles in such a manner that will prevent contamination.

Unless otherwise directed by the Engineer, fine aggregate of various gradations and from different sources shall be stockpiled separately.

**1003.02** Fine Aggregate for Portland Cement Concrete and Mortar. The aggregate shall conform to the requirements of Article 1003.01 and the following specific requirements:

- (a) Description. The fine aggregate shall consist of washed sand. Stone sand will be permitted for portland cement concrete provided it is blended with natural sand in the proportions satisfactory to the Engineer.
- (b) Quality. The fine aggregate materials in the gradations specified for portland cement concrete shall be Class A Quality. The fine aggregate for mortar for masonry shall be from natural aggregate pits approved for Class A Quality or shall meet the deleterious quantity limits for Class A Quality.
- (c) Gradation. The fine aggregate for portland cement concrete shall be Gradation FA 1. When permitted, Gradation FA 2 may be used in lieu of FA 1. Fine aggregate for mortar for masonry shall be Gradation FA 9.
- (d) Mixing Fine Aggregates. The mixing, alternate use, and/or substitution of fine aggregates from different sources for use in portland cement concrete will not be permitted without the approval of the Engineer. When mixing is permitted, the method of combining the fine aggregates shall be such as to produce a consistently uniform mixture, and the arrangements for mixing shall be satisfactory to the Engineer.

**1003.03** Fine Aggregate for Bituminous Mixtures. The aggregate shall conform to the requirements of Article 1003.01 and the following specific requirements:

- (a) Description. Fine aggregate for bituminous mixtures shall consist of sand, stone sand, slag sand or chats. For Class I, all types, steel slag sand will also be allowed. Fine aggregate for top dressing of bituminous surfaces shall consist of sand, stone sand, stone screenings, chats, wet bottom boiler slag, slag sand or steel slag sand.
- (b) Quality. The fine aggregate for bituminous mixtures Class I, all types shall be Class B Quality or better.

The fine aggregate for Class B mixtures, where the Class B mixture aggregate is composed of separate sizes, shall be Class C Quality or better. The fine aggregate used as blotter material on oiled earth surface where the required curing period is not feasible shall be a hard durable material reasonably free of soft and unsound particles.

(c) Gradation. The fine aggregate gradations shall be as follows:

For Class I, all types, the gradation shall be FA 1, FA 2 or FA 20. For Class I, Types 2 and 3, FA 21 may also be used. For Class I, Types 2 and 3, the FA 21 gradation shall consist of stone sand, slag sand or steel slag sand only, or a mechanical blend of stone sand, slag sand or steel slag sand and natural sand.

Gradation FA 1, FA 2 or FA 3 shall be used when required for prime coat aggregate application for Class I and Class B.

Gradation FA 7 shall be used when specified. Gradation FA 1, FA 2, FA 3 or FA 4 shall be used for blotter material on oiled earth surfaces where the required curing period is not feasible.

(d) Source of Supply. All sources of supply shall be approved by the Engineer. The Contractor shall submit to the Engineer a statement giving the sources of fine aggregate. Only fine aggregates from these sources shall be used on the job unless approval in writing is obtained from the Engineer.

1003.04 Fine Aggregate for Trench Backfill, Sand Backfill for Underdrains, Bedding, Porous Granular Backfill and French Drains. The aggregate shall conform to the requirements of Article 1003.01 and the following specific requirements:

- (a) Description. The fine aggregate shall consist of sand, stone sand, stone screenings, chats, wet bottom boiler slag, slag sand or granulated slag sand. Crushed concrete sand and construction and demolition debris sand may be used in lieu of the above for trench backfill.
- (b) Quality. The fine aggregate shall be reasonably free from an excess of soft and unsound particles and other objectionable matter.
- (c) Gradation. The fine aggregate for trench backfill shall be Gradation FA 6. The fine aggregate for porous granular embankment and backfill and french drains, sand backfill for underdrains and bedding shall be Gradation FA 1

or FA 2, except the percent passing the 75  $\mu m$  (No. 200) sieve shall be 2±2.

- **1003.05** Fine Aggregate for Membrane Waterproofing. The aggregate shall conform to the requirements of Article 1003.01 and the following specific requirements:
  - (a) Description. The fine aggregate shall consist of sand, stone sand, wet bottom boiler slag, slag sand or chats.
  - (b) Quality. The fine aggregate shall meet the Class B Quality Deleterious Count, and when subjected to 5 cycles of the Department's sodium sulfate soundness test (AASHTO T 104), the weighted average loss shall not be more than 10 percent.
  - (c) Gradation. The fine aggregate shall be Gradation FA 8.

#### **SECTION 1004. COARSE AGGREGATE**

- **1004.01 Materials.** The aggregate materials shall conform to the following requirements:
  - (a) Description. The natural and manufactured materials used as coarse aggregate are defined as follows:

Gravel. Gravel shall be the coarse granular material resulting from the reduction of rock by the action of the elements and having subangular to rounded surfaces. It may be partially crushed.

Chert Gravel. Chert gravel shall be the coarse granular material occurring in alluvial deposits resulting from reworking by weathering and erosion of chert bearing geological formations and containing a minimum of 80 percent chert or similar siliceous material.

Crushed Gravel. Crushed gravel shall be the product resulting from crushing by mechanical means, and shall consist entirely of particles obtained by crushing gravel, all of which before crushing will be retained on a screen with openings equal to or larger than the maximum nominal size of the resulting crushed material. If approved by the Engineer, final product gradations may be obtained by screening or blending various sizes of crushed gravel material.

Pit or Bank Run Gravel. Pit or bank run gravel shall be a mixture of sand, gravel, silt and clay occurring naturally in a deposit, which is of such quality that it may be used with only minor processing.

Novaculite Gravel. Novaculite gravel shall be material occurring in natural deposits, composed of angular particles of siliceous origin and mixed with ferruginous clay.

Crushed Stone. Crushed stone shall be the angular fragments resulting from crushing by mechanical means the following types of rocks quarried from undisturbed, consolidated deposits: granite and similar

phanerocrystalline igneous rocks, limestone, dolomite, sandstone, or massive metamorphic quartzite, or similar rocks. Dolomite shall be a carbonate rock containing 11.0 percent or more magnesium oxide (MgO). Limestone shall be a carbonate rock containing less than 11.0 percent magnesium oxide (MgO).

Wet Bottom Boiler Slag. Wet bottom boiler slag shall be the hard, angular by-product of the combustion of coal in wet bottom boilers.

Crushed Slag. Crushed slag shall be the graded product resulting from the processing of air cooled blast furnace slag. Air cooled blast furnace slag shall be the nonmetallic product, consisting essentially of silicates and alumino-silicates of lime and other bases, which is developed in a molten condition simultaneously with iron in a blast furnace. It shall be air cooled and shall have a compact weight (AASHTO T 19) of not less than 1100 kg/m<sup>3</sup> (70 lbs./cu. ft.).

Crushed Sandstone. Crushed sandstone shall be the angular fragments resulting from crushing, by mechanical means, a cemented sand composed predominantly of quartz grains.

Crushed Concrete. Crushed concrete shall be the angular fragments resulting from crushing portland cement concrete by mechanical means. The acceptance and use of crushed concrete shall be according to the latest Bureau of Materials and Physical Research policy memorandum.

Chats. Chats shall be the tailings resulting from the separation of metals from the rocks in which they occur.

Crushed Steel Slag. Crushed steel slag shall be the graded product resulting from the processing of steel slag. Steel slag shall be the nonmetallic product which is developed in a molten condition simultaneously with steel in an open hearth, basic oxygen or electric furnace.

Crushed Copper Slag. Crushed copper slag shall be the graded product resulting from the processing of copper slag. Copper slag shall be the non-metallic product developed in a molten condition simultaneously with copper in a smelter.

(b) Quality. The coarse aggregate shall be from an approved source and shall meet the quality standards listed in the following table and will be accepted on the basis of these tests unless unfavorable conditions showing up in usage indicate the material is unsatisfactory. All coarse aggregate materials shall meet the specified quality requirements before being proportioned for mix or combined to adjust gradation.

COARSE AGGREGATE QUALITY					
		CLA	ASS		
QUALITY TEST	Α	В	С	D	
Na <sub>2</sub> SO <sub>4</sub> Soundness <sup>2/</sup> 5 Cycle, AASHTO T 104 <sup>1/2/</sup> Max. % Loss Los Angeles Abrasion AASHTO T 96 Max. % Loss Minus 75 µm (No. 200) Sieve Mat'l. AASHTO T 11 Max. % Deleterious Mat'ls. <sup>7/</sup> - Shale Max. % - Clay Lumps Max. % - Coal & Lignite Max. % - Soft & Unsound Frag. Max. % - Other Deleterious Max. % - Total Deleterious Max. %	15 40 <sup>4</sup> / 1.0 <sup>8</sup> / 1.0 0.25 0.25 4.0 4.0 <sup>11</sup> / 5.0	15 40 <sup>5/</sup> 2.0 0.5 6.0 2.0 6.0	20 40 <sup>6</sup> / 2.5 <sup>9</sup> / 4.0 <sup>10</sup> / 0.5 <sup>10</sup> / 8.0 <sup>10</sup> / 2.0 <sup>10</sup> / 10.0 <sup>10</sup> /	25 <sup>3/</sup> 45	

- 1/ As modified by the Department.
- 2/ Does not apply to crushed concrete.
- 3/ For aggregate surface course, the maximum percent loss shall be 30.
- 4/ For portland cement concrete, the maximum percent loss shall be 45.
- 5/ Does not apply to crushed slag or crushed steel slag.
- 6/ For Class I Bituminous Binder Courses and Bituminous Base Course, except when used as Surface Course, the maximum percent loss shall be 45.
- 7/ Crushed concrete for all allowable Class C quality and Class D quality uses shall meet the Class C quality deleterious count, except the clay lump requirement shall not apply for Class C quality seal coat use and for all Class D quality uses.
- 8/ For crushed aggregate, if the material finer than the 75  $\mu$ m (No. 200) sieve consists of the dust from fracture, essentially free from clay or silt, this percentage may be increased to 2.5.
- 9/ Does not apply to aggregates for Class I Binders, Class B Mixtures, and Bituminous Base Course Mixtures.
- 10/ Does not apply to Class A Seal and Cover Coats except when Note 7 applies.
- 11/ Includes deleterious chert. In gravel and crushed gravel aggregate, deleterious chert shall be the lightweight fraction separated in a 2.35 heavy media separation. In crushed stone aggregate, deleterious chert shall be the

lightweight fraction separated in a 2.55 heavy media separation.

All varieties of chert contained in gravel coarse aggregate for portland cement concrete, whether crushed or uncrushed, pure or impure, and irrespective of color, will be classed as chert and shall not be present in the total aggregate in excess of 25 percent by mass (weight).

Aggregates used in handrail, parapet, end post, and all other superstructure concrete shall contain no more than 2 percent total by mass (weight) of deleterious materials or substances whose disintegration is accompanied by an increase in volume which may cause spalling of the concrete.

At the time of use, the coarse aggregate shall be free from frozen materials and all foreign materials which may have become mixed with it during handling. Cars used for shipping the aggregate shall not be caulked with hay, straw, excelsior, grass or similar materials.

(c) Gradation. The coarse aggregate shall be uniformly graded from coarse to fine and, when tested by means of laboratory sieves (square openings), shall conform to the designated gradation.

The sizes prescribed may be manufactured by any suitable commercial process and by the use of any sizes or shapes of plant screen openings necessary to produce the sizes within the limits of the sieve analysis specified.

The gradation numbers and corresponding gradation limits are listed in the following table and represent the limits which will determine suitability for use from all approved sources of supply. The gradation of the material from any one source shall be reasonably close to the gradation specified and shall not be subject to the extreme percentages of gradation represented by the tolerance limits for the various sieve sizes. The sizes are based on the use of square opening sieves in making analysis.

	COARSE AGGREGATE GRADATIONS <sup>1</sup> /										
					Sieve Siz cent Pas						
Grad 75 No. mm	63 mm	50 mm	37.5 mm	25 mm	19 mm	12.5 mm	9.5 mm	4.75 mm	1.18 mm	300 μm	75 μm <b>2/</b>
CA 1 100	95±5	60±15	15±15	3±3							
CA 2	100	95±5		75±15		50±15		30±10	20±15		8±4
CA 3	100	93±7	55±20	8±8		3±3					
CA 4		100	95±5	85±10		60±15		40±10	20±15		8±4
CA 5			97±3 <b>3/</b>	40±25		5±5		3±3			
CA 6			100	95±5		75±15		43±13	25±15		8±4
CA 7			100	95±5		45±15 <b>4</b>	./	5±5			
CA 8			100	97±3	85±10	55±10		10±5	3 <u>+</u> 3 <b>5/</b>		
CA 9			100	97±3		60±15		30±15	10±10		6±6
CA 10				100	95±5	80±15		50±10	30±15		9±4
CA 11				100	92±8	45±15	6/	6±6	3±3 <b>6/5</b>	5/7/	
CA 12					100	95± 5	85±10	60±10	35±10		9±4
CA 13					100	97±3	80±10	30±15	3±3 <b>5/</b>		
CA 14						90±108	45±20	3±3			
CA 15						100	75±15	7±7	2±2		
CA 16						100	97±3	30±15	2±2 <b>5/</b>		
CA 17 100								65±20	45±20	20±10	10±5
CA 18 100				95±5				75±25	55±25	10±10	2±2
CA 19 100				95±5				60±15	40±15	20±10	10±5

	COARSE AGGREGATE GRADATIONS <sup>1</sup> / (ENGLISH)										
	Sieve Size Percent Passing										
Grad No. 3"	2 1/2"	2"	1 1/2"	1"	3/4"	1/2"	3/8"	No. 4	No. 16	No. 5	0No. 200 <b>2/</b>
CA 1 100	95±5	60±15	15±15	3±3							
CA 2	100	95±5		75±15		50±15		30±10	20±15		8±4
CA 3	100	93±7	55±20	8±8		3±3					
CA 4		100	95±5	85±10		60±15		40±10	20±15		8±4
CA 5			97±3 <b>3/</b>	40±25		5±5		3±3			
CA 6			100	95±5		75±15		43±13	25±15		8±4
CA 7			100	95±5		45±15 <sup>4</sup>	V	5±5			
CA 8			100	97±3	85±10	55±10		10±5	3 <u>+</u> 3 <b>5/</b>		
CA 9			100	97±3		60±15		30±15	10±10		6±6
CA 10				100	95±5	80±15		50±10	30±15		9±4
CA 11				100	92±8	45±15	6/	6±6	3±3 <b>5/</b>	7/	
CA 12					100	95± 5	85±10	60±10	35±10		9±4
CA 13					100	97±3	80±10	30±15	3 <u>+</u> 3 <b>5/</b>		
CA 14						90±10	45±20	3±3			
CA 15						100	75±15	7±7	2±2		
CA 16						100	97±3	30±15	2±2 <b>5/</b>		
CA 17 100								65±20	45±20	20±1	0 10±5
CA 18 100				95±5				75±25	55±25	10±1	0 2±2
CA 19 100				95±5				60±15	40±15	20±1	0 10±5



- 1/ When an optional range is specified, once the range is selected, it shall not be changed.
- 2/ Subject to Maximum percent allowed in Coarse Aggregate Quality Table.
- 3/ Shall be 100 percent passing the 45 mm (1 3/4") sieve.
- 4/ When using gradation CA 7 for A binder, the percent passing the 12.5 mm (1/2") sieve may also be 35±10 or 15±10.
- 5/ When used in Class I Bituminous Mixtures, the percent passing the 1.18 mm (No. 16) sieve for gradations CA 8, CA 11, CA 13 or CA 16, shall be 4±4%.
- 6/ When using gradation CA 11 for B binder, the percent passing the 12.5 mm (1/2") sieve may also be 15±10.
- 7/ The 1.18 mm (No. 16) requirement will be waived when CA 11 is used in the manufacture of portland cement concrete.
- 8/ 100 percent passing 16 mm (5/8") sieve.
- (d) Incompatibility. Incompatibility of any of the gradations or combinations of gradation permitted resulting in unworkable mixtures, nonadherence to the final mix gradation limits, or any other indication of incompatibility shall be just cause for rejection of one or both of the sizes.
- (e) Storage of Coarse Aggregate. Sites for stockpiles shall be grubbed and

cleaned prior to storing the aggregates.

The stockpiles shall be built in layers not exceeding 1.5 m (5 ft.) in height, and each layer shall be completely in place before the next layer is started. A stockpile may be expanded by again starting the expansion from the ground and building layers as before. End dumping over the sides will not be permitted. Steel track equipment will not be permitted on stockpiles of specified Class A Quality coarse aggregate. When loading out of stockpiles, vertical faces shall be limited to reasonable heights to eliminate segregation due to tumbling. Aggregate producer's stockpiling methods currently in use and proven satisfactory to the Engineer may be continued at the source. Segregation or degradation due to improper stockpiling or loading out of stockpiles shall be just cause for rejecting the material.

Separate stockpiles shall be provided for the various kinds of aggregates. Stockpiles shall be separated to prevent intermingling at the base. If partitions are used, they shall be of sufficient heights to prevent intermingling. Coarse aggregates for portland cement concrete and bituminous mixtures shall be handled in and out of the stockpiles in such a manner that will prevent contamination and degradation.

Crushed slag for portland cement concrete shall be stockpiled in a moist condition (saturated surface dry or greater) and the moisture content shall be maintained uniformly throughout the stockpile by periodic sprinkling.

**1004.02** Coarse Aggregate for Portland Cement Concrete. The aggregate shall conform to the requirements of Article 1004.01 and the following specific requirements:

- (a) Description. The coarse aggregate shall be gravel, crushed gravel, crushed stone, crushed concrete, crushed slag or crushed sandstone.
- (b) Quality. The coarse aggregate shall be Class A quality.
- (c) Gradation. The gradations of coarse aggregate used in the production of portland cement concrete for pavements and structures shall be as listed in Table 1. included in Article 1020.04. The sizes prescribed may be manufactured by any suitable commercial process. Washing equipment will be required where producing conditions warrant.
- (d) Combining Sizes. Each size shall be stored separately and care shall be taken to prevent them from being mixed until they are ready to be proportioned. The Engineer reserves the right to determine as the work progresses the proportions of the separated sizes of coarse aggregate which, when combined with fine aggregate, cement and water according to these Specifications, will produce the most workable mixture. The Contractor will be permitted to mix more than 2 sizes of coarse aggregate, provided the separate sizes selected and the proportions used in combining them are approved by the Engineer and that separate compartments are provided to proportion each size.

At the option of the Contractor, a unit coarse aggregate Gradation CA 7 or CA 11 may be used for any portland cement concrete. When a unit coarse aggregate is used, the cement factor shall be not less than 335 kg/m<sup>3</sup>

### Coarse Aggregate

(5.65 hundredweight/cu. yd.), except that if the concrete is produced by a truck mixed or shrink mixed operation, the cement content shall be not less than 359 kg/m<sup>3</sup> (6.05 hundredweight/cu. yd.).

If the coarse aggregate is furnished in separate sizes, they shall be combined in proportions to provide a uniformly graded coarse aggregate grading within the following limits:

				Percer	nt Passing	Sieves		
Class of Concrete <sup>1/</sup>								
	Combined Sizes	63 mm	50 mm	45 mm	37.5 mm	25 mm	12.5 mm4	l.75 mm
PV, PP and SH <sup>2/</sup>								
,	CA 5 & CA 7			100	98±2	72±22	22±12	3±3
	CA 5 & CA 11			100	98±2	72±22	22±12	3±3
MS and SC <sup>2</sup> /								
	CA 3 & CA 7	100	95±5			55±25	20±10	3±3
	CA 3 & CA 11	100	95±5			55±25	20±10	3±3
	CA 5 & CA 7			100	98±2	72±22	22±12	3±3
	CA 5 & CA 11			100	98±2	72±22	22±12	3±3

					ENGLISH : Passing			
Class of Concrete <sup>1/</sup>								
	Combined Sizes	2 1/2"	2"	1 3/4"	1 1/2"	1"	1/2"	No. 4
PV, PP and SH <sup>2/</sup>								
I v, i i and oii	CA 5 & CA 7			100	98±2	72±22	22±12	3±3
	CA 5 & CA 11			100	98±2	72±22	22±12	3±3
MS and SC2/								
	CA 3 & CA 7	100	95±5			55±25	20±10	3±3
	CA 3 & CA 11	100	95±5			55±25	20±10	3±3
	CA 5 & CA 7 CA 5 & CA 11			100 100	98±2 98±2	72±22 72±22	22±12 22±12	3±3 3±3

- 1/ See Table 1 of Article 1020.04.
- 2/ Any of the listed combination of sizes may be used.
- (e) Mixing Gravel, Crushed Gravel, Crushed Stone and Crushed Slag Coarse Aggregates. Two different specified sizes of crushed stone, gravel and crushed gravel from one source or any 2 sources may be combined in any consistent ratio in a mix, but the use of alternate batches of crushed stone, gravel or crushed gravel of any one size or combination of sizes will not be permitted. Coarse aggregates of any one size from different sources shall not be mixed without permission from the Engineer. Crushed slag shall not be combined or mixed with gravel, crushed gravel or crushed stone

aggregates.

(f) Freeze-Thaw Rating. When coarse aggregate is used to produce portland cement concrete pavement, base course, base course widening, shoulders, or the repair using concrete, the gradation permitted will be determined from the results of the Department's Freeze-Thaw Test. A list of freeze-thaw ratings for all A-quality coarse aggregate sources will be available. The gradations permitted for each rating shall be as follows:

Freeze-Tha (Top	o Size)	Gradation Permitted
mm	inch	
40 mm	(1-1/2 inches)	Combined CA 5 & CA 7, Combined CA 5 & CA 11, CA 7, or CA 11
25 mm	(1 inch)	CA 7, or CA 11
20 mm	(3/4 inch)	CA 11
13 mm	(1/2 inch)	CA 14
N.A.		Not Acceptable

Additional requirements may be placed on coarse aggregates when used in continuously reinforced concrete pavement. Such requirements will be stipulated on the most recent Freeze-Thaw Rating List.

## 1004.03 Coarse Aggregate for Bituminous Courses.

(a) Description. The coarse aggregate for all bituminous mixtures except Class I Surface Mixture E shall be crushed gravel, crushed stone (other than limestone), crushed sandstone, crushed slag, or chats. For Class I, Type 1 and 2 Surface Mixture E, the coarse aggregate shall be crushed slag, crushed steel slag, crushed sandstone, or a blend in equal proportions by volume of crushed slag, crushed steel slag or crushed sandstone with crushed gravel, chats, or a crushed stone other than limestone. Additional coarse aggregate for the other specific bituminous mixtures may also be used according to the following table:

Class	Use	Additional Coarse Aggregate Types Permitted
А	Seal or Cover	Gravel Crushed Concrete Crushed Steel Slag Limestone
В	Mixture	Gravel Crushed Concrete Limestone
I, Type 2	Mixture A	Limestone
I, Type 3	Mixture A	Limestone Novaculite Gravel
I, Type 1 and 2	Mixture B	Limestone
I, Type 3	Mixture B	Limestone Novaculite Gravel
I, Type 1 and 2	Mixture C	Crushed Steel Slag Limestone
I, Type 3	Mixture C	Limestone Novaculite Gravel
I, Type 1 and 2	Mixture D	Crushed Steel Slag Limestone <sup>1/</sup>



- 1/ Limestone may be used in Mixture D if blended in equal proportions by volume with crushed slag, crushed steel slag, crushed sandstone, or novaculite coarse aggregate.
- (b) Quality. For Class A and B bituminous courses, the coarse aggregate shall be Class C quality or better. For Class I, Type 1, 2 and 3 surface courses and Class I, all types binder courses when used as surface course, the coarse aggregate shall be Class B quality or better. For other courses, the coarse aggregate shall be Class C quality or better.
- (c) Gradation. The coarse aggregate gradations shall be as listed in the following table. For Class I mixtures, specified gradations other than those listed in the Table will be allowed if the Contractor provides a mix design indicating that all the mixture criteria stated in Section 406 will be met.

Class	Use	Gradation No.
A-1, 2 & 3 A-1 A-2 & 3 B I Type 2 & 3 I Type 1, 2 & 3 I Type 1, 2 & 3	Seal 10 mm (3/8") Seal 13 mm (1/2") Cover Mixture Mixture A Mixture B Mixture C, D & E	CA 16 CA 15 CA 14 CA 6 <sup>1</sup> /or CA 10 <sup>1</sup> / CA 7 <sup>2</sup> /or CA 8 <sup>3</sup> / CA 11 <sup>4</sup> / CA 13 <sup>5</sup> /or CA 16

1/ In Class B Mixture aggregate where the aggregates are deficient in fines, the material added to compensate shall not be soil materials such as clay, loam or silt. The material added to make up deficiencies shall be a granular material approved by the Engineer. Plasticity Index of Class B Mixture material shall not exceed 4.

Gradation CA 12 may be used in lieu of CA 6 or CA 10, when specified. When lifts of nominal 45 mm (1 3/4 inches) or less compacted thickness are placed, Gradations CA 10 or CA 12 shall be used. The required gradation may be obtained by blending aggregates of Class C Quality or better. The gradation of the individual aggregates shall be approved by the Engineer. When the aggregates are blended, aggregate feeders for each size shall be provided according to Article 1102.01(d). If Mineral Filler is used, the mineral filler equipment requirements under Article 1102.01(d)(5) or (d)(9) shall apply.

- When directed by the Engineer, CA 13 or CA 16 shall be blended with CA 7 for Class I Types 2 and 3, Mixture A.
- 3/ Gradation CA 8 for Class I Mixture A may, at the option of the Contractor, be obtained by blending either gradation CA 7 or CA 7 (as modified in Article 1004.01(c), Note 4) with CA 13 or CA 16.
- 4/ When directed by the Engineer, CA 13 or CA 16 shall be blended with CA 11 for Class I, Types 1, 2, and 3, Mixture B.
- 5/ Gradation CA 16 shall be used in lieu of CA 13 when the bituminous course is designed for 30 mm (1 1/4 inches) or less in thickness.
- (d) Sources of Supply. All sources of supply shall be approved by the Engineer. The Contractor shall submit to the Engineer a statement giving the sources of the coarse aggregate. Only coarse aggregates from these sources shall be used on the job unless approval in writing is obtained from the Engineer.

1004.04 Coarse Aggregate for Aggregate Surface Course, Granular Embankment Special, Aggregate and Stabilized Aggregate Base, Subbase and Shoulder Courses. The aggregate shall conform to the requirements of

Article 1004.01 and the following:

(a) Description. The coarse aggregate shall be pit run gravel, gravel, crushed gravel, novaculite, crushed stone, crushed concrete, crushed slag or crushed sandstone, except that pit run gravel and gravel shall not be used for subbase Granular Material, Type C.

The granular material for stabilized aggregate base, subbase, and shoulder courses, if approved by the Engineer, may be produced by blending aggregates from more than one source, provided the method of blending results in a uniform product. The components of a blend need not be of the same kind of material. The source of material shall not be changed during the progress of the work without written permission from the Engineer. Where a natural aggregate is deficient in fines, the material added to make up deficiencies shall be a material approved by the Engineer.

- (b) Quality. The coarse aggregate shall be Class D Quality or better.
- (c) Gradation. The coarse aggregate gradation shall be used as follows:

For aggregate surface course Type B, Gradation CA 6, CA 9, or CA 10 may be used. If approved by the Engineer, Gradation CA 4 or CA 12 may be used.

For aggregate subbase Type B, Gradation CA 6, CA 10, CA 12, or CA 19 shall be used. If approved by the Engineer, Gradation CA 2 or CA 4 may be used.

For aggregate subbase Type C, Gradation CA 7 as specified in Article 1004.01 or combined size CA 5 and CA 7 as specified in Article 1004.02 shall be used. If separate sizes are furnished, combining by proper mixing will be required either at the source or at the jobsite.

For granular aggregate courses (base, subbase, and shoulder except subbase Types B and C), Gradation CA 6 shall be used. If specified, Gradation CA 2 or CA 4 may be used in lieu of CA 6.

Stabilized aggregate courses (base, subbase, and shoulder), Gradation CA 6, or CA 10 shall be used. If specified, Gradations CA 2, CA 4, or CA 12 may be used in lieu of CA 6 or CA 10.

For Aggregate Surface Course, Type A and granular embankment special, CA 6 or CA 10 shall be used. If approved by the Engineer, Gradation CA 2, CA 4, CA 9, or CA 12 may be used in lieu of CA 6 or CA 10.

(d) Plasticity. All material shall comply with the plasticity index requirements listed below. The plasticity index requirement for crushed gravel, crushed stone and crushed slag may be waived if the ratio of the percent passing the 75  $\mu m$  (No. 200) sieve to that passing the 425  $\mu m$  (No. 40) sieve is 0.60 or less.

	Plasticity	y Index - Percent 1/
Type of Construction	Gravel	Crushed Gravel, Stone & Slag
Granular Embankment, Special	0 to 6	0 to 4
Aggregate Subbase Type A Type B	0 to 9 0 to 9	
Aggregate Shoulders Type A Type B	2 to 9 2 to 9	
Aggregate Base Course Type A Type B	0 to 6 0 to 6	0 to 4 0 to 4
Aggregate Surface Course Type A Type B <sup>2/</sup>	2 to 9 2 to 9	
Stabilized Aggregate Mat'l.	0 to 9	0 to 9

- 1/ Plasticity Index shall be determined by the method given in AASHTO T 90. Where shale in any form exists in the producing ledges, crushed stone samples shall be soaked a minimum of 18 hours before processing for plasticity index or minus 425  $\mu$ m (No. 40) material. When clay material is added to adjust plasticity index, the clay material shall be in a minus 4.75 mm (No. 4) sieve size.
- 2/ When Gradation CA 9 is used, the plasticity index requirement will not apply.
- **1004.05** Coarse Aggregate for Membrane Waterproofing. The aggregate shall conform to the requirements of Article 1004.01 and the following specific requirements:
  - (a) Description. The coarse aggregate shall be gravel, crushed gravel, crushed stone, crushed concrete, crushed slag, crushed sandstone or chats.
  - (b) Quality. The coarse aggregate shall consist of tough durable particles reasonably free of objectionable material and, when subjected to 5 cycles

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# Coarse Aggregate

of the sodium sulphate soundness test (AASHTO T 104), the weighted average loss shall not be more than 15 percent.

- (c) Gradation. The coarse aggregate shall be Gradation CA 16.
- **1004.06** Coarse Aggregate for Blotter, Embankment, Backfill, and French **Drains.** The aggregate shall conform to the requirements of Article 1004.01 and the following specific requirements:
  - (a) Description. The coarse aggregate shall be gravel, crushed gravel, pit run gravel, crushed stone, crushed concrete, crushed slag, chats, crushed sandstone or wet bottom boiler slag.
  - (b) Quality. The coarse aggregate shall consist of sound durable particles reasonably free of objectionable deleterious material.
  - (c) Gradation. The coarse aggregate gradation shall be as follows:

Diottei	CA	10
Nonporous Granular Embankment and Backfill	CA	17

Porous Granular Embankment and Backfill, and French Drains ..... CA 18

**1004.07 RAP Materials.** RAP material is reclaimed asphalt pavement material resulting from the cold milling or crushing of an existing hot-mix bituminous concrete pavement structure. Original pavement materials shall be crushed coarse aggregate of Class C quality (Class B quality for Surface Course), or better. The Contractor shall inform the Engineer as to the location of the originally placed pavement and/or the origin of existing stockpiled RAP prior to being used.

Any RAP that cannot be readily broken down in the mixing process and/or affects paving operation shall be processed over a "grizzly" prior to introduction into the mixture. All over sized aggregates in the RAP shall be reduced to the maximum size permitted for the mixture being produced.

The blending proportions may be changed during the progress of the job with prior approval of the Engineer.

RAP stockpiles shall be separated by type of aggregate (crushed natural aggregate, steel slag, or blast furnace slag). RAP containing contaminants, such as earth, brick or sand, will be unacceptable until the contaminants are thoroughly removed. Sheet Asphalt shall be stockpiled separately.

The Contractor may provide documented quality control information, satisfactory to the Engineer, that defines the gradation and asphalt content of a processed stockpile.

Note: RAP containing high percentages of volatile petroleum solvents may be a fire or explosion hazard when heated.

# Stone, Concrete Blocks and Broken Concrete for Erosion Protection, Sediment Control, and Rockfill

Art. 1005.01

# SECTION 1005. STONE, CONCRETE BLOCKS AND BROKEN CONCRETE FOR EROSION PROTECTION, SEDIMENT CONTROL, AND ROCKFILL

1005.01 Stone for Erosion Protection, Sediment Control, and Rockfill. Stone, sediment, and rockfill shall meet the following requirements:

- (a) Description. The material shall be stone quarried from undisturbed, consolidated deposits of rock reasonably free of shale and shaly stone. The ledges shall be sufficiently thick to produce the desired dimensions. The stone shall be reasonably free of laminations, seams, cracks and other structural defects or imperfections tending to destroy its resistance to weather. Field stone or boulders will not be accepted. Bedding material shall be crushed stone, crushed gravel, crushed sandstone, or crushed slag. The crushed slag shall meet the Department's "Test for Leachate".
- (b) Quality. Stone for erosion protection, sediment control or rockfill shall be quarried from ledges meeting one of the listed quality designations. All ledges shall be sufficiently thick to produce the desired dimensions. Ledges shall be checked with rock samples sized to CA-7/11 and run in the IDOT sodium sulfate soundness test. Bedding material shall be tested in its manufactured gradation in the Department's sodium sulfate soundness test.

Quality Designation

Designation	<u>Bennidon</u>
Α	The stone shall not exceed 15% sodium sulfate soundness loss. Elongated pieces (length is greater than 5 times average thickness) shall not exceed 10% by weight. The stone shall have a specific gravity (dry) greater than 2.45 when checked in a full gradation product.
В	The stone shall not exceed 25% sodium sulfate soundness loss. Elongated pieces (length is greater than 5 times average thickness) shall not exceed 10% by weight.
С	The stone shall only have to conform to the above paragraph (a), Description.

Definition

(c) Gradation. Stone for erosion protection or sediment control shall meet one of the gradation number designations listed in the following table. All gradations produced shall be well-graded. A minimum of one gradation check for each gradation produced shall be run during initial production each year. Additional checks may be done by visual inspection if no gradation problem exists.

Stone, Concrete Blocks and Broken Concrete for Erosion Protection, Sediment Control, and Rockfill 1

Art.	1005.0
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BEDDING MATERIAL									
	Sieve Size Percent Passing								
GRAD. NO.	100 mm	75 mm	50 mm	37.5 mm	4.75 mm				
1		100		53±23	8±8				
2	100		53±23		8±8				

BEDDING MATERIAL (ENGLISH)									
	Sieve Size Percent Passing								
GRAD. NO.	4"	3"	2"	1 1/2"	No. 4				
1		100		53±23	8±8				
2	100		53±23		8±8				

# Stone, Concrete Blocks and Broken Concrete for Erosion Protection, Sediment Control, and Rockfill Art. 1005.01

EROSION PROTECTION, SEDIMENT CONTROL, AND ROCKFILL														
						Rock S Percent								
Grad. No.	455 <sup>1/</sup>	270 <sup>1/</sup>	180 <sup>1/</sup>	135	75	70 <sup>1/</sup>	40	201/	18	5	4	3	1	0.5
3 <sup>2/</sup>								100			50±20			8±8
4						100			50±20					8±8
5			100				50±20						8±8	
6	-	100	Ť		50±20	)	, i	, i				8±8	·	
7	100			50±20						8±8				

		EROSION PR	ROTEC	CTION,	SEDIM (ENG		CONTR	OL, AN	D RO	CKFILL			
Grad. No.	1000 <sup>1/</sup>	600 <sup>1</sup> / 400 <sup>1</sup> /	300	170	1501/	90	<sub>50</sub> 1/	40	12	10	6	3	1
32/							100			50±20			8±8
4					100			50±20					8±8
5		100				50±20	1					8±8	
6		100		50±20	)						8±8		
7	100		50±20						8±8				

- 1/ 5% by weight may be oversize. Each oversize piece shall not exceed the maximum size of the gradation by more than 20%.
- 2/ When used for aggregate ditch check, Gradation 3 may be modified as follows: Percent Passing: 20 kg (50 lb.) - 100; 1.5 kg (3 lbs.) - 50±20; 0.5 kg (1 lb.) - 8±8.
- (d) Usage. Stone for use as erosion protection and sediment control shall be designated by class. The class shall be a combination of a quality designation and a gradation designation. The various uses with their allowable classes shall be specified by the designer according to the latest Bureau of Materials and Physical Research policy memorandum.

Rockfill shall meet Quality Designation #C and may be shot rock, primary crusher run, or other specified gradations.

Art. 1005.02

1005.02 Concrete Blocks and Broken Concrete for Riprap. The concrete blocks shall be cast solid; shall be made from aggregates meeting all requirements for physical properties, soundness, and wear specified in Articles 1003.02 and 1004.02 and shall contain not less than 340 kg (565 lbs.) bags of portland cement per cubic meter (cubic yard) of concrete. The concrete shall have a minimum compressive strength of not less than 24 MPa (3500 psi) at the age of 14 days, as determined by the Engineer, either from tests of entire blocks or from tests of blocks subdivided by sawing or drilling into prisms or cylinders. Specimens for testing will be selected by the Engineer at such intervals as will ensure control of the production of blocks. The blocks may be made from plastic concrete, or they may be machine made, utilizing the type of equipment ordinarily employed in the fabrication of building blocks.

- (a) Blocks Produced from Plastic Concrete. The blocks shall be made from concrete containing not less than 4 nor more than 7 percent entrained air and having a slump of not more than 40 mm (1 1/2 inches). The concrete shall be consolidated in the molds by vibratory equipment and in a manner meeting the approval of the Engineer. The blocks shall be finished to uniform and true dimensions.
- (b) Machine Made Blocks. The concrete shall be made with aggregate sizes and of a consistency suitable for production of the blocks by machine methods. The concrete shall have an air-entrainment (Note 1) meeting the approval of the Engineer. The blocks shall be of uniform and true dimensions.
  - Note 1. The experience in the manufacture, inspection and use of machine made blocks for riprap is very limited. It is known that air-entrained concrete of the type and consistency suitable for manufacture of the blocks will also contain entrapped air. Available test methods do not differentiate between the two, and some experimentation may be necessary at the beginning of the production. Manufacturers in general have had little experience in the manufacture of blocks from mixtures having cement contents as high as specified herein, and some adjustment of the usual proportion of fine to coarse aggregate may be required, in order that the equipment may work satisfactorily.
- (c) Size of Blocks. The concrete blocks shall conform, to the minimum dimensions, 200 mm x 200 mm x 400 mm (8" x 8" x 16") concrete building block.
- (d) Broken Concrete. The material shall be made from newly broken, sound concrete pavement or other suitable concrete debris from demolished concrete construction having a minimum thickness of 150 mm (6 inches) between unbroken surfaces. Concrete showing excessive popping, spalling, cracking or any other type of disintegration indicating poor resistance to weathering will not be acceptable. No reinforcing steel or other such material shall be protruding from the broken pieces. The gradation or sizing of the pieces shall conform to Article 1005.01(c).

Metals Art. 1006.01

### **SECTION 1006. METALS**

**1006.01 Corrugated Steel Pipe and Corrugated Steel Pipe Arch.** The thickness and masses for different covers shall be as specified in Tables I and II of Article 542.03.

- (a) Corrugated Steel Culvert Pipe and Corrugated Steel Pipe Arch. The pipe and arch shall conform to the requirements of AASHTO M 36M (M 36).
  - Helically Corrugated Steel Culvert Pipe. The sawed or torch cut ends of helically corrugated steel culvert pipe shall be coated with a zinc metallizing process, aluminum asphalt paint or other methods approved by the Engineer. Helically corrugated steel culvert pipe shall conform to the requirements of AASHTO M 36M (M 36), except that all fabrication weld repairs shall meet the weld seam tolerance. No damage shall be repaired or painted without prior approval of the Engineer. Welded helically corrugated pipe that has 2 rows of circumferential corrugations fabricated on each end may be field connected with an approved hugger type band.
- (b) Bituminous Coated Corrugated Steel Culvert Pipe and Bituminous Coated Corrugated Steel Pipe Arch. This pipe and pipe arch shall conform to the requirements of AASHTO M 190, Type A. Bituminous coating for the connecting bands will not be required. Any bituminous coating damaged in shipment, during installation, or prior to final acceptance shall be repaired by the Contractor to the satisfaction of the Engineer.
- (c) Precoated Galvanized Corrugated Steel Culvert Pipe and Precoated Galvanized Corrugated Steel Pipe Arch. The precoated steel sheets used to fabricate these items shall conform to AASHTO M 246M (M 246), Grade 10/3. The precoated culvert pipe and pipe arch shall conform to the requirements of AASHTO M 245M (M 245), except that the sheet thickness for the respective diameters of pipe and fill heights shall be as specified in Tables IB and IIA of Article 542.03. The sawed ends of helically corrugated pipe shall be coated with a zinc metallizing process, aluminum asphalt paint or other methods approved by the Engineer.

Precoating for the connecting bands will not be required.

- (d) Perforated Corrugated Steel Pipe. This pipe shall conform to the requirements of AASHTO M 36M (M 36) except that when a fine aggregate backfill is used, perforations shall have a nominal diameter of 5 mm (3/16 inch).
- (e) Precoated Fully-Lined Galvanized Corrugated Steel Pipe and Precoated Fully-Lined Galvanized Corrugated Steel Pipe Arch. This pipe and arch shall meet the requirements as specified in (c) above except that coupling bands shall be precoated and shall be of the hugger or annular type. Additionally, the entire interior of the pipe or arch shall be covered with a centrifugally applied lining having a minimum thickness of 3 mm (1/8 inch) above the crests of the inside corrugations. When rivets are used in the fabrication of the pipe or arch, they shall be located in the valleys of the corrugations inside the pipe or arch. The lining material shall conform to AASHTO M 190 unless otherwise permitted, and the surface of the lining shall be smooth and uniform.

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- (f) Precoated PVC Lined Galvanized Corrugated Steel Pipe. The precoated steel sheets used to fabricate this pipe shall conform to AASHTO M 246M (M 246), Type A, with the polymeric coating on the outside of the pipe. The pipe shall have two annular corrugations and a 15 mm (1/2 inch) upturned flange square with the longitudinal axis of the pipe at each end of each length of pipe. The PVC liner shall be a minimum of 1 mm (0.055 inch) thick and shall conform to ASTM D 1784 cell class 13343-B. Longitudinal seams shall have a minimum 50-mm (2-inch) single lap, and circumferential seams shall be butt joints with a minimum 25-mm (1-inch) wide backup strip of the same material. All seams shall be chemically welded and the ends of the PVC liner shall be bent to form a flange which is adhesive cemented to the steel pipe flange at each end of each length of pipe. The annular space between the steel pipe shell and the PVC liner shall be filled with a closed cell urethane foam conforming to ASTM D 2341 cell class 3306669883 which when foamed in place has a minimum density of 32 kg/m<sup>3</sup> (2 lbs./cu. ft.). Coupling bands shall be precoated and shall be of the flange type. Gaskets shall meet the requirements of ASTM F 477 and shall be capable of meeting the leakage requirements of ASTM C 443M (C 443).
- (g) Precoated Smooth Lined Corrugated Steel Pipe and Precoated Smooth Lined Corrugated Steel Pipe Arch. This pipe or arch shall conform to AASHTO M 246M (M 246) except that the steel sheet used shall be coated with a polymer coating of 0.25 mm (0.010-inch) minimum thickness on the exposed faces of both the outer shell and the inner liner. The outer shell and the inner liner shall be lock seamed together or otherwise attached integrally to each other at helical seams spaced not more than 750 mm (30 inches) apart. The pipe or arch shall have two annular corrugations and a 15 mm (1/2-inch) upturned flange square to the longitudinal axis of the pipe or arch at each end of each length of pipe or arch. Coupling bands shall be precoated and shall be of the channel type. Gaskets shall meet the requirements of ASTM F 477, shall totally cover the peripheries of abutting flanges and shall be capable of meeting the leakage requirements of ASTM C 443M (C 443). The mass per meter (foot) of precoated smooth lined corrugated steel pipe or arch shall not be less than the mass per meter (foot) of a standard corrugated steel pipe or arch of the steel thickness shown in Article 550.03. The inner liner shall have a minimum thickness of 1 mm (0.040 inch) and the outer shell shall have a minimum thickness of 60 percent of the steel thickness shown in Article 550.03.
- (h) Zinc and Aramid Fiber Composite Coated Corrugated Steel Pipe. Zinc and aramid fiber composite coated corrugated steel pipe shall conform to the requirements of AASHTO M 36M (M 36).
- (i) Aluminized Steel Type 2 Corrugated Culvert Pipe and Corrugated Pipe Arch. This Pipe shall conform to AASHTO M 274 and M 36.
- 1006.02 Corrugated Structural Plate Pipe, Pipe Arches, and Arches. Corrugated steel structural plate pipe, pipe arches and arches that are fabricated and erected in sections shall conform to the requirements of AASHTO M 167M (M 167). Corrugated aluminum alloy structural plate pipe, pipe arches and arches that are fabricated and erected in sections shall conform to the requirements of AASHTO M 219M (M 219).

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1006.03 Corrugated Aluminum Alloy Pipe and Corrugated Aluminum Alloy Culvert Pipe Arch. These Specifications cover corrugated aluminum alloy culvert pipe, bituminous coated corrugated aluminum alloy culvert pipe, corrugated aluminum alloy culvert pipe arch, bituminous coated corrugated aluminum alloy culvert pipe arch, helically corrugated aluminum alloy culvert pipe, perforated corrugated aluminum alloy pipe and semicircular aluminum alloy pipe. The thickness for different depths of cover shall be as specified in Table I and Table II of Article 542.03.

- (a) Corrugated Aluminum Alloy Culvert Pipe and Corrugated Aluminum Alloy Culvert Pipe Arch. The pipe or arch shall conform to the requirements of AASHTO M 196M (M 196), except the lot number may be shown instead of the processing date.
- (b) Bituminous Coated Corrugated Aluminum Alloy Culvert Pipe and Bituminous Coated Corrugated Aluminum Alloy Culvert Pipe Arch. The coating for the pipe or arch shall conform to the requirements of AASHTO M 190 Type A.

The uncoated pipe shall conform to Article 1006.03(a). Bituminous coating for the connecting bands will not be required.

(c) Helically Corrugated Aluminum Alloy Culvert Pipe. This pipe may be used as an alternate and shall conform to the requirements of AASHTO M 196M (M 196), except as follows:

Pipe having a diameter of 250 mm (10 inches) or less shall have corrugations not less than 35 mm (1 3/8 inches) nor more than 48 mm (1 7/8 inches) center-to-center, measured at right angles to the direction of the corrugations and shall have a depth of not less than 6 mm (1/4 inch).

Pipe having a diameter of 300 mm (12 inches) or greater shall have corrugations not less than 48 mm (1 7/8 inches) nor more than 70 mm (2 3/4 inches) center-to-center, measured at right angles to the direction of the corrugations. Pipe having diameters of not less than 300 mm (12 inches) nor more than 525 mm (21 inches) shall have corrugation depth of not less then 11 mm (7/16 inches). Pipe having diameters greater than 525 mm (21 inches) shall have corrugation depth of not less than 13 mm (1/2 inch). Pipe with helical corrugations shall have a continuous lock seam extending from end to end of each length of pipe. The seams shall be fabricated in such a manner that they will not affect the shape or nominal diameter of the pipe, and so they will not create an element of weakness in the pipe.

(d) Perforated Corrugated Aluminum Alloy Pipe. This pipe shall conform to the requirements of AASHTO M 196M (M 196), except the lot number may be shown instead of the processing date and perforations shall have a nominal diameter of 5 mm (3/16 inch)

**1006.04 Structural Steel.** Structural steel shall conform to the requirements of AASHTO M 270M Grade 250 (M 270 Grade 36), except bar stock conforming to ASTM A 576 Special Quality Steel with similar mechanical properties and chemical composition, may be used.

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- (a) Rollers. Rollers may be made from any of the following materials:
  - (1) Structural steel having a minimum tensile strength of 400 MPa (58,000 psi), a minimum yield point of 250 MPa (36,000 psi), a minimum elongation of 20 percent, and conforming in all other respects to AASHTO M 270 Grade 36.
  - (2) Rollers, 225 mm (9 inches) or less in diameter, may be made from cold finished bars conforming to AASHTO M 169, Grades 1016 to 1030 inclusive.
  - (3) Forgings shall conform to the requirements of AASHTO M 102, Class C.
- (b) Steel Posts, Blockouts, Restraints and Wire Rope for Guardrail. Steel posts and blockouts shall conform to the requirements of AASHTO M 270M Grade 250 (M 270 Grade 36) or ASTM A 769M Grade 250 or 280 (A 769 Grades 36 or 40), except when "C" shape posts and blockouts for guardrail are used, they shall conform to the requirements of AASHTO M 270M Grade 250 (M 270 Grade 36) or ASTM A 570M Grade 250 or 280 (A 570 Grades 36 or 40), with a maximum tensile strength of 550 MPa (80,000 psi). Steel restraints shall conform to the requirements of AASHTO M 227M Grade 485 through 555 (M 227 Grades 70 through 80). Steel posts and restraints shall be galvanized according to AASHTO M 111. Wire rope for cable assemblies shall be according to AASHTO M 30, Class A coating.
- (c) Pins. Pins shall conform to SAE 8620 Material.

**1006.05 Metal Shell and Sheet Piling.** Metal shell and sheet piling shall conform to the following:

- (a) Metal Shell Piling. All shells without taper shall conform to the requirements of ASTM A 252. The steel for fluted, tapered shells shall have a minimum tensile strength of 345 MPa (50,000 psi).
- (b) Sheet Piling. Steel sheet piling shall be of the size and shape as specified on the plans and conform to the requirements of AASHTO M 202M (M 202).

**1006.06** Transverse Tie Rods and Dowel Rods. Transverse tie rods and dowel rods shall conform to the following:

- (a) Transverse Tie Rods. Steel for transverse tie rods shall conform to the requirements of AASHTO M 227M Grade 485 trhough 555 (M 227 Grades 70 through 80), AASHTO M 31M (M 31) or M 53M (M 53) plain bars. After fabrication, the transverse tie assemblies (tie rods, nuts, washers and sleeves) shall be hot-dipped galvanized according to AASHTO M 232. The small articles may be zinc-coated by the mechanically deposited process conforming to AASHTO M 298, Class 50. The thickness of the mechanical galvanizing shall not exceed 150 μm (6 mils).
- (b) Dowel Rods. Steel for dowel rods shall conform to the requirements of AASHTO M 227M Grades 485 through 555 (M 227 Grades 70 through 80), AASHTO M 31M (M 31) or M 53M (M 53).

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**1006.07** Turned and Ribbed Bolts. Low carbon steel turned and ribbed bolts shall conform to the requirements of ASTM A 307, Grade C.

**1006.08 High-Strength Steel Bolts, Nuts, and Washers.** High-strength steel bolts, nuts and washers shall conform to the requirements of AASHTO M 164M (M 164), except as modified by the Specifications for Structural Joints using AASHTO M 164M (M 164) Bolts, approved by the Research Council on Structural Connections of the Engineering Foundation.

When galvanizing is specified, the zinc coating shall be by the mechanical plating method conforming to AASHTO M 298, Class 50. The thickness of the mechanical galvanizing shall not exceed 150 µm (6 mils). Zinc-coated nuts shall be tapped oversize according to the requirements of AASHTO M 291M (M 291) and shall meet the supplementary requirements of S1.1 thru S1.2.1 of the same specifications for lubricant and testing. The lubricant shall be tinted to produce a distinct contrast with the nut.

**1006.09 Anchor Bolts.** All anchor bolts and nuts, shall conform to ASTM A 307 except that nonheaded anchor bolts either straight or bent may conform to AASHTO M270, Grade 250 (M 270, Grade 36), AASHTO M 31M (M 31) or M 53M (M 53) with a maximum tensile strength of 655 MPa (95,000 psi).

All anchor bolts shall be of the type and dimensions as shown on the plans. If not shown on the plans, a minimum radius of bend approximately 4 times the nominal diameter shall be used. Expansion hook bolts, which are to be used as dowels, shall contain an approved anchoring device providing the following minimum certified proof load according to tensile testing requirements of ASTM E 488 for the specified hook bolt diameter:

HOOK BOLT	PROOF LOAD
M16 (5/8")	22 kN (5000 lbs.)
M20 (3/4") M22 (7/8")	33 kN (7500 lbs.) 35 kN (8000 lbs.)

Anchor bolts, nuts and washers requiring galvanizing shall be completely coated by either the hot-dipped process conforming with AASHTO M 232 or the mechanical plating method conforming to AASHTO M 298, Class 50. The thickness of the mechanical galvanizing shall not exceed 150  $\mu$ m (6 mils).

Non-headed anchor bolts shall be galvanized for a minimum length of 250 mm (10 inches) from the threaded end.

#### 1006.10 Concrete Reinforcement Bars, Fabric, and Strand.

 (a) General Conditions. All fabrication shall be done at the mill or shop prior to shipment.

No substitutions shall be made without the approval of the Engineer. Approval shall be obtained before the bars or fabric are fabricated or ordered. At the time of shipment, the surface of all reinforcement bars, fabric, and prestressing strands shall be free from loose mill scale, dirt, oil, grease, or other foreign substances. A light coating of rust, which may form during storage under acceptable conditions at the mill or warehouse, will

not be deemed cause for rejection. Stocks of reinforcement bars, fabric, or strand either at the mill or warehouse, which have not been protected in an adequate manner during storage, will not be accepted.

At the time the bars and fabric are placed in the work, they shall be free from rust which pits the surface or scales off, dirt, oil, grease or other foreign substances. A light coating of rust, which may form during storage on the work under acceptable conditions, will not be deemed cause to require cleaning. Thin powdery rust and tight rust is not considered detrimental and need not be removed.

# (b) Reinforcement Bars.

General. Reinforcement bars, including epoxy coated reinforcement bars, shall conform to the requirements of AASHTO M 31M (M 31) or M 53M (M 53), Grade 300 (40) or 400 (60), or AASHTO M 42M (M 42), Grade 400 (60) deformed bars. In addition to the other requirements in AASHTO M 31M (M 31), bars larger than No. 35 (No. 11) that are to be bent shall comply with the requirements for Bending Properties of AASHTO M 31M (M 31). For these bend tests requirements, the diameter of the pin shall be 9 times the diameter of the specimen, and the bend shall be 90 degrees. Bars fabricated by the producer according to AASHTO M 42M (M 42) shall comply with the bend test requirements of AASHTO M 42M (M 42). The Bending Requirements of AASHTO M 42M (M 42) will not apply when rail steel bars are used for longitudinal bars in continuously reinforced concrete pavement. Spiral reinforcement for concrete columns and concrete piers shall be deformed or plain bars conforming to the requirements of AASHTO M 31M (M 31), M 42M (M 42) or M 53M (M 53), or cold-drawn steel wire conforming to AASHTO M 32.

Longitudinal bars for continuously reinforced concrete pavement shall be AASHTO M 31M (M 31), M 42M (M 42) or M 53M (M 53) Grade 400 (60) deformed bars. The transverse bars may be either AASHTO M 31M (M 31) or M 53M (M 53), Grade 300 (40) or Grade 400 (60) deformed bars, except that transverse bars to which chairs are to be welded, the bars across the longitudinal joint, and bars which are to be bent shall be Grade 300 (40), except the elongation shall not be less than 20% for bent bars straightened in the field.

(2) Epoxy Coated Reinforcement Bars. Epoxy coated reinforcement bars shall conform to the requirements of AASHTO M 284M (M 284).

Coating material shall be any one of the epoxy resin powders which have been prequalified by the National Bureau of Standards and approved by the Engineer.

Bars may be sheared or sawn to length after coating, provided end damage to coating does not extend more than 15 mm (1/2 inch) back and the cut end is patched before any visible oxidation appears. Flame cutting will not be permitted.

The coating applicator shall furnish to the Engineer at the time of shipment written certification that the coated reinforcement bars were

cleaned, coated, and tested according to the requirements of AASHTO M 284M (M 284).

In addition to the requirements of AASHTO M 284M (M 284) for continuity of coating, no more than 8 of the holidays permitted shall be in any 300 mm (1 ft.) length of bar.

- (c) Reinforcement Fabric for Portland Cement Concrete Pavement.
  - (1) Welded Wire Fabric. Welded wire fabric shall conform to the requirements of AASHTO M 55. Welded wire fabric for concrete pavement may be furnished in either flat sheets or hinged sheets. The method of hinging the sheets shall meet the approval of the Engineer.
  - (2) Bar Mat Fabric. Bar mat fabric shall conform to the requirements of AASHTO M 54M (M 54). Longitudinal bars shall be Grade 60. The fabric shall be furnished either in flat sheets or hinged flat sheets.
- (d) Prestressing Steel Strand. Prestressing steel strand shall conform to the requirements of AASHTO M 203.

1006.11 Pavement Longitudinal Metal Joints, Dowel Bars, Expansion Joint Assembly, Contraction Joint Assembly, and Hinge Joint Assembly.

- (a) Pavement Longitudinal Metal Joint, Pins and Bar Supports. Longitudinal metal joint for pavement, pins for installing the joint and supports for bars in pavement shall be as specified.
- (b) Dowel Bars. Dowel bars shall be plain, round bars conforming to the requirements of AASHTO M 227M Grades 485 through 555 (M 227 Grades 70 through 80). The finished bars shall be saw cut and free from burrs or out-of-round ends which will prevent their slipping easily in the concrete. The bars shall be epoxy coated according to the requirements of AASHTO M 254.
- (c) Expansion Joint Assembly. The expansion joint assembly shall be an approved welded assembly utilizing wire sizes corresponding to the requirements for contraction joint assemblies and shall have a joint width conforming to the requirements shown on the plans.
- (d) Contraction or Hinge Joint Assembly. The contraction or hinge joint assembly shall be an approved welded assembly possessing the rigidity to hold the epoxy coated dowel or epoxy coated reinforcement bar during the placing and compacting of the concrete to the degree of alignment specified. The assembly shall have 4 parallel spacer bars for contraction joints, 2 parallel spacer bars for hinge joints, and 2 subgrade bearing members for both. An upright bar support at each end of each dowell or reinforcing bar shall be welded to both the outside spacer bar and the bearing member at appropriate points to hold the bars at the design height. For contraction joints, the 2 inside spacer bars shall be spaced approximately 50 mm (2 inches) on each side of the center.

The bars shall be spaced as shown on the plans. The alternate ends of epoxy coated dowel bars and every end of epoxy coated reinforcement bars



shall be welded to the outside spacer bars or the upright bar. Weld areas, and cut or sheared ends on the epoxy coated reinforcement bars need not be patched with epoxy. One weld is permitted per dowel bar. The end of each dowel not welded to a spacer bar shall be held securely in place by means of wire loops or metal tubes welded to the other outside spacer bar. Suitable ties shall be provided to hold the contraction joint assembly in normal position during shipping, handling and installation. Wire sizes shall be not less than W7 for the outside spacer bars, bearing member and upright supports and W5 wire for the 2 inside spacer bars on contraction joint assemblies. The tire wires used for securing the spacer bars shall be not less than W3 wires.

The assembly shall be provided with 2 continuous bearing plates of not less than 50-mm (2-inch) width and not less than 0.9-mm (0.0359-inch) thickness sheet steel. The bearing plates shall be attached by welding to the subgrade members or by suitable clips and shall be punched to receive the protruding ends of the upright supports and stakes. The stakes shall be driven parallel to and next to the upright supports. The subgrade bearing members may be omitted if suitable subgrade plates are shop welded to the assembly and provide equivalent rigidity. Bearing plates will not be required on stabilized subbases. The welds in the assembly shall be securely made. A broken weld will be sufficient cause for the rejection of the length or section of the assembly in which it occurs.

**1006.12 Steel Forgings.** Steel forgings shall conform to the requirements of AASHTO M 102 and shall be the class specified.

**1006.13 Steel Castings.** Steel castings shall conform to the requirements of AASHTO M 192M (M 192) and shall be of the class specified. When required by the Engineer for the purpose of inspection, castings shall be suspended for tapping and examination of all surfaces.

**1006.14 Gray Iron Castings.** Gray iron castings shall be according to AASHTO M 105 and AASHTO M 306. Castings shall be Class 35. Tensile tests will be required and standard test specimens shall be furnished without charge. The permissible variations of AASHTO M 306 shall be modified as follows:

- (a) Other dimensions (+ 1/4 inch).
- (b) Weight (+20 percent drawing/specification weight).

The lid or grate of all castings within the area of the pavement or gutter shall so fit and have contact with the frame as to ensure the lid or grate from jumping or rattling when struck by vehicles.

All frames within the area of the pavement or gutter having circular lids shall have the bearing surfaces of the lid and frame machined or ground so that there will be no variation from a circular, straight edge, of the dimensions corresponding to the lid bearing surface. The diameter of the lid shall be such as to fit the frame without wedging.

Castings for frames, grates and lids shall be proof loaded according to AASHTO M 306. Certification of the test results shall be provided to the Engineer.

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**1006.15 Ductile Iron Castings.** Ductile iron castings shall conform to the requirements of ASTM A 536.

Casting for frames, grates and lids shall be fabricated of Grade 65-45-12. Castings lying within the area of the pavement or gutter shall meet the same requirements as specified in Article 1006.14 for gray iron casting.

Casting for frames, grates and lids shall be proof loaded as specified in Article 1006.14.

- **1006.16 Malleable Castings.** Malleable castings shall conform to the requirements of ASTM A 47M (A 47), Grade No. 32510.
- 1006.17 Steel Rods, Turnbuckles, Bolts, Washers and Other Metal Fastenings for Timber Structures. Steel rods shall be SAE 1020 or other steel meeting the approval of the Engineer. Turnbuckles shall be drop-forged and conform in dimensions and mass (weight) of the latest Manual of the American Institute of Steel Construction. The distance between the heads shall be 150 mm (6 inches). Bolts shall be U.S. Standard. Lag screws and nails shall be standard form. Washers may be cast, malleable or cut steel.

After fabrication, the rods, turnbuckles, bolts, washers, and other metal fasteners shall be galvanized by the hot-dip process. The zinc coating shall conform to the requirements of AASHTO M 232.

- **1006.18 Steel Pipe.** Steel pipe shall be of the size and mass (weight) specified and shall conform to the requirements of ASTM A 53. The pipe shall be black.
- **1006.19** Cast Iron Water Pipe. Cast iron water pipe shall conform to Federal Specifications WW-P-421 for Pipe; Water, Cast-Iron (Bell and Spigot). The pipe shall be of the size and class specified.
- **1006.20 Cast Iron Soil Pipe.** Cast iron soil pipe and fittings shall conform to Federal Specifications WW-P-401 for Pipe and Pipe-Fittings; Soil, Cast-Iron. The pipe shall be of the grade known commercially as "Extra Heavy".
- **1006.21 Cast Bronze Plates.** Cast bronze for bearing and expansion plates shall conform to the requirements of AASHTO M 107. The bronze shall be Alloy B unless otherwise specified.
- **1006.22** Rolled Copper-Alloy Plates. Rolled copper-alloy for bearing and expansion plates shall conform to the requirements of AASHTO M 108, Alloy 510.
- **1006.23** Lead Plates. Lead plates shall be uniform in thickness and have a workmanlike finish. They shall be dimensioned as follows:

Thickness	kg/m <sup>2</sup> (lb./sq. ft.)
1.5 mm (1/16")	18 (3 3/4)
3 mm (1/8")	37 (7 1/2)
6 mm (1/4")	75 (15)
10 mm (3/8")	110 (22 1/2)

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- **1006.24 Copper Strip or Sheet.** Copper strip or sheet shall be cold-finished and annealed, soft or 1/8 hard temper, meeting the requirements of AASHTO M 138. The sheet shall stand being bent cold through an angle of 180° flat upon itself without fracture on the outside of the bent portion.
- 1006.25 Steel Plate Beam Guardrail. The bolts and nuts for connections shall be of the design shown on the plans, and shall conform to the requirements of ASTM A 307, Class A. The bolts and nuts shall be galvanized with zinc coating conforming to the requirements of AASHTO M 232 or AASHTO M 298, Class 50. The thickness of the mechanical galvanizing shall not exceed 150  $\mu$ m (6 mils).

Steel plate beam guardrail shall conform to the requirements of AASHTO M 180, Type I, Class A.

In order to prevent rapid oxidation of the zinc coating, the Contractor shall protect all galvanized rail elements, end sections, splice plates, posts and accessories from rain, snow, and other weathering conditions while they are stored on the site prior to installation. This protection shall consist of storing the galvanized parts for the guardrail off the ground surface, so that they will not come in contact with surface run-off water, and properly covering the parts on the top and on all sides. The Contractor shall use special care in storing the rail elements, end sections, and splice plates so that no moisture gets between the pieces when they are stacked in contact with each other.

When erected, the surfaces of the rail elements, end sections, and splice plates shall have a bright finish and shall not be tarnished. If "white rust" (zinc oxide) has formed on any of the surfaces of the rail elements, end sections, and splice plates, the affected material will be rejected by the Engineer.

# 1006.26 Cables, Springs, Accessories, Offset Brackets, and Spring Expansion Take-ups for Cable Road Guard.

- (a) Cables and Fastenings. Wire cable and fastenings for cable road guard shall conform to the requirements of AASHTO M 30, Class A Wire Rope.
- (b) Springs. All springs shall be made from spring steel conforming to the requirements of ASTM A 689, except that the silicon requirements may be waived.
- (c) Rods, Turnbuckles, Bolts and Washers. The steel used in the manufacture of the rods shall comply with the requirements of the latest revision of SAE 1020 or other steel meeting the approval of the Engineer. Turnbuckles shall be drop-forged and conform in dimensions to the latest Manual of the American Institute of Steel Construction. Bolts shall be U.S. Standard. Lag screws and nails shall be standard form. Washers may be cast, malleable, or cut steel.
  - After fabrication, the springs, rods, turnbuckles, bolts and washers shall be galvanized according to the requirements of AASHTO M 232. The small articles may be zinc-coated by the mechanically deposited process conforming to AASHTO M 298, Class 50. The thickness of the mechanical galvanizing shall not exceed 150  $\mu$ m (6 mils).
- (d) Offset Brackets. The type and design of brackets will be limited to those which have been approved by the Engineer and for which approved plans

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and Specifications are on file with the Department. The brackets shall be one of the following types:

- (1) Offset Spring Brackets. The offset spring brackets shall have a deflection of 25 mm (1 inch) under a compression load of not less than 15.5 kN (3500 lbs.) and not more than 26 kN (6000 lbs.) applied for one minute perpendicular to the line of the cables with the cables in place. Upon release of the load, the brackets shall show a permanent set or deformation of not more than 10 mm (3/8 inch). The permanent set or deformation shall be measured between the points of attachment of the bracket and the cable and the base of the bracket. The offset spring brackets shall not collapse under a compression load of 45 kN (10,000 lbs.).
- (2) Special Offset Spring Brackets. Special offset spring brackets of the blunt, slotted, overlapping nose type shall be fabricated from spring steel tempered and drawn. The brackets with steel stay pins shall be slotted for 3 cables. Special offset spring brackets shall have a minimum deflection of 25 mm (1 inch) under a compression load of 67 kN (15,000 lbs.) applied for one minute perpendicular to the line of the cables at the points of attachment of the cables and the bracket with the cables in all slots. Upon release of the load, the bracket shall show a permanent set or deformation of not more than 13 mm (1/2 inch), measured on the outside limits of the bracket from front to back. A manufacturing tolerance of ± 3 mm (1/8 inch) will be allowed in the height and width of the special offset spring bracket.
- (e) Spring Expansion Take-ups. The end spring expansion take-ups shall consist of one coil spring, one cable end fitting for 19-mm (3/4-inch) wire cable and 19-mm (3/4-inch) rods and nuts. It shall be designed for attachment to the end or anchor posts. The spring shall be of sufficient strength to provide a 125-mm (5-inch) take-up in a 19-mm (3/4-inch) wire cable 150 m (500 ft.) long.

## 1006.27 Chain Link Fence.

- (a) Fabric. The fabric shall be according to one of the following:
  - (1) The fabric shall be woven in 50 mm (2 inch) mesh with 3.75 mm (0.148 inch) diameter wire meeting one of the following requirements of AASHTO M 181:
    - a. Type I, Class D (zinc-coated steel)
    - Type II (aluminum-coated steel)
    - c. Type III (aluminum alloy)
    - d. Type IV, Class B (polyvinyl chloride (PVC)-coated steel). When vinyl-coated fabric is used, the posts, fence framework, gates, tension wire, fabric ties, and fittings shall be vinyl-coated according to the same requirements as the coating of the fabric. All nonaluminum material shall be galvanized prior to vinyl coating.

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- (2) Fabric shall be according to ASTM F 1345, woven in 50 mm (2-inch) mesh with 3.75 mm (0.148 inch) diameter wire protected by Class 2 mischmetal coating. The weight of Zn 5A1 MM alloy coating shall not be less than 305 g/m<sup>2</sup> (1.0 oz. per sq. ft.) of uncoated wire surface.
- (b) Metal Posts. Metal posts, rail, braces, and gate frames shall be the shape and dimension as shown on the plans and shall meet the bending strength and dimension tolerance of AASHTO M 181.

Pipe and rolled shapes shall conform to ASTM F 669, Table 2. Metallic coating shall conform to ASTM F 1234, Table 2. Square hollow structural steel tubing shall conform to ASTM A 500 Grade B or ASTM A 501, with ASTM F 1234, Type A internal and external coating.

- (c) Tension Wire. Tension wire shall conform to the requirements of AASHTO M 181, Type I, Class 2, or Type II.
- (d) Fabric Ties. The fabric ties to be used with other than vinyl-coated fabric shall be stainless steel hog rings (minimum diameter [3 mm (0.120 inch)], 9-gage aluminum wire or 9-gage galvanized steel wire with 370 g/m² (1.2 oz per sq. ft.) zinc coating. The fabric ties to be used with vinyl fabric shall be of the same material as the fabric.
- (e) Fittings. All miscellaneous fittings shall be made of malleable cast iron or pressed steel and shall be galvanized according to AASHTO M 232.
- (f) Bolts and Nuts. All bolts and nuts shall conform to the requirements of ASTM A 307 and shall be zinc-coated according to AASHTO M 232 or AASHTO M 298, Class 50 with galvanizing not to exceed 150  $\mu$ m (6 mils).

### 1006.28 Woven Wire Fence.

- (a) Woven Wire Fencing. Woven wire fencing may be either galvanized steel wire fencing or aluminum-coated steel wire fencing. Galvanized steel wire fencing shall conform to the requirements of AASHTO M 279, Class 3, Design Number 939-6-11. Aluminum-coated steel wire fencing shall conform to the requirements of ASTM A 584, Design Number 939-6-11.
- (b) Barbed Wire. Barbed wire may be either galvanized steel barbed wire or aluminum-coated steel barbed wire consisting of 2 strands of 12 1/2-gage wire with 4-point barbs of 14-gage wire spaced 125 mm (5 inches) apart.

Galvanized barbed wire shall conform to the Specifications for zinc-coated (galvanized) steel barbed wire, AASHTO M 280, Class 3 with a minimum coating of 245 g/m² (0.80 oz. per sq. ft.) of wire surface.

Aluminum-coated steel barbed wire shall conform to the Specifications for galvanized steel barbed wire, except the wire shall be aluminum coated. The wire shall have not less than 76 g (0.25 oz.) coating of aluminum alloy per square meter (square foot) of uncoated surface. The weight of the aluminum alloy coating shall be determined according to AASHTO T 213.

(c) Brace Wires. Brace wires shall be galvanized or aluminum alloy coated

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- No. 9 gage steel wire conforming to the Specifications for galvanized steel or aluminum alloy coated fencing.
- (d) Metal Posts. Metal posts shall be the shapes and dimensions shown on the plans. Line posts shall include a firmly attached, tapered anchor plate having an area of not less than 12000 mm² (18 sq. inches). The anchor plate shall be fabricated from not less than 12 gage thickness steel. Steel pipe for metal posts shall be steel pipe, Type A, Type B, or Type C according to Article 1006.27. Structural shapes for posts shall be fabricated from steel conforming to the requirements of AASHTO M 281, Grades A or B. All structural shapes shall be galvanized according to AASHTO M 111 using zinc of any grade conforming to the requirements of AASHTO M 120. The zinc coating shall be not less than 610 g/m² (2.0 oz. per sq. ft.) of surface.

Square hollow structural tubing shall conform to the requirements of ASTM A 500, Grade B or ASTM A 501. The tubing shall be galvanized inside and outside according to AASHTO M 111, using zinc of any grade conforming to the requirements of AASHTO M 120. The coating shall be not less than 610 g/m<sup>2</sup> (2.0 oz. per sq. ft.) of surface.

- (e) Metal Braces. Metal braces shall have the shapes and dimensions shown on the plans. They shall conform to the Specifications for metal posts, either steel pipe or structural shapes, and shall be galvanized as specified for the metal posts.
- (f) Gate Frames. Gate frames shall consist of galvanized steel pipe having the dimensions shown on the plans and conforming to the specifications for steel pipe line posts.
- (g) Miscellaneous Materials. Miscellaneous materials such as, but not limited to, wire, clips, or other metal devices for fastening the barbed wire and fencing to the posts, shall be of good commercial quality and galvanized. Staples shall be at least 38 mm (1 1/2 inches) long of No. 9 galvanized wire.
- (h) Post Tops. Steel pipe and steel tubing posts shall be furnished with steel or malleable iron or wrought iron post tops of approved type, and shall be galvanized according to AASHTO M 232.

1006.29 Metal Posts and Hardware for Highway Markers, Signs and Delineators. Metal posts for highway markers, signs and delineators shall conform to the following requirements except that delineator posts shall be unfinished steel.

- (a) Post Materials.
  - (1) Steel. The steel used in the posts shall be hot rolled conforming to the physical properties of ASTM A 499, Grade 60 and to the chemical properties of ASTM A 1 for 41-kg (91-lb.) or for larger steel rails.
  - (2) Aluminum. The aluminum used in the posts shall conform to the requirements of ASTM B 221M (B 221), Alloy 6061-T6, which shall meet the following minimum requirements:

Tensile strength	260 MPa (38,000 psi)
Yield point	240 MPa (35,000 psi)
Elongation 50 mm (2 inch)	10 percent

#### (b) Fabrication and Finish:

(1) Mass (Weight). The average mass (weight) of the posts per meter (foot) of length shall be not less than the following:

	Kilograms per Meter (P	ounds per Foot)
Type of Post	Aluminum	Steel
A B C	1.3 (0.90) 1.9 (1.30) 	3.0 (2.00) 4.5 (3.00) 1.7 (1.12)

Individual posts shall not vary more than 10 percent below their average weight.

- (2) Punching. In the case of steel posts, all punching or drilling shall be done prior to galvanizing.
- (3) Galvanized Steel Posts. Steel posts shall be galvanized by the hot-dip process according to AASHTO M 111.
- (4) Enameled Steel Posts. Steel posts shall be painted with a weather resistant, rust inhibitive, high quality, dark green enamel which shall produce a hard mar resistant coating, free from paint cracks, blisters, or other defects. The quality of the paint shall be such that when the finished post is struck a light blow with a sharp tool, the paint shall not crack or chip, and if scratched with a knife, shall not powder. The thickness of the dry film enamel shall be a minimum of 25 μm (1 mil.). It shall pass the standard 100 hour salt spray test [20% solution by spray of fog 21 °C (70 °F.)]. Painting shall be the final process after all fabrication and punching has been completed.

The enamel for steel posts shall have the following properties:

Solids by Mass (Minimum)	54.6%
Mass kg/L (lbs./gal.) (Minimum)	1 (8.6)
Viscosity at 25 °C (77 °F.)	45-50 sec.
	No. 4 Ford
60% Gloss	High
Method of Application	Flow Coat
Cure Schedule 150 °C (300 °F.)	20 minutes

(5) Polyester Coated Steel Posts. Steel posts shall be coated with an electrostatically applied powder coating of a dark green, pigmented, Metals Art. 1006.29

urethane-cured, polyester having the following properties:

Polyester Resin (Molecular weight equivalent	
2,000-5,000)	. 40-75%
Blocked Isocyanate Curing Agent	
(Molecular weight equivalent 1,000-3,000)	. 10-25%
Flow Control Agent (Acrylo-terpolymers)	
Exterior Durable Grade Pigment and Extender	. 25-50%
Organic Volatile Content (Maximum)	3%

The posts shall be cleaned free of oil, loose mill scale and rust by pickling or by blast cleaning to near white with a blast profile not greater than 50  $\mu$ m (2 mils.). They shall then be pretreated with 430 to 750 mg/m<sup>2</sup> (40 to 70 mg/ft.<sup>2</sup>) of iron phosphate and chemically sealed.

The coating shall be applied immediately after cleaning as an electrostatically charged dry powder sprayed onto the grounded post using an electrostatic spray gun. The thickness of the applied coating shall be a minimum of 63  $\mu$ m (0.0025 inch) measured on a flat surface of the post according to ASTM D 1186.

All systems for handling the coated posts shall have padded contact areas. All bundling bands shall be padded or suitable banding shall be used to prevent damage to the coating. The posts or bundles shall not be dropped or dragged. The bundled posts shall be transported with care and stored above the ground on wooden or padded supports.

(6) Workmanship and Finish. The posts shall be symmetrical and well formed. They shall be free from injurious defects which will impair their strength or appearance. The zinc coating on the steel posts shall be free from such imperfections as lumps, blisters, uncoated spots, dross, and flux.

## (c) Tests.

- (1) Tension Tests. The tensile properties of the metals shall be determined by the method outlined in AASHTO T 68.
- (2) Tests for Weight of Zinc Coating. The weight of the zinc coating shall be determined by the method outlined in AASHTO M 111. As an option, the weight of the coating may be determined by weighing one or more full size specimens after pickling and drying and again after coating.
- (3) Tests for Polyester Coating. The coated posts shall be capable of meeting the following requirements:

Impact. The coating shall show no cracks or breaks when subjected to an impact of 11 J (100 in.-lbs.) according to ASTM D 2794.

Salt Spray. When tested for 500 hours according to ASTM B 117, no rust, blisters or undercutting of uncoated or scribed areas will be apparent.

Humidity. There shall be no blistering of the coating or gloss loss greater than 5 percent when tested according to ASTM D 2247.

Weathering. There shall be no more than 15% loss of gloss and no appreciable color change when tested for 1,000 hours in a carbon arc weatherometer according to ASTM G 23, Type EH.

- (4) Certification. When steel posts are supplied, the Contractor shall furnish a certification from the manufacturer that the posts meet the specified chemical and physical properties. The Department reserves the right to test samples for these and other requirements of these Specifications.
- (d) Hardware. Hardware for attaching sign panels to posts and other applications shall be zinc coated steel or stainless steel.

Steel bolts, nuts, and washers shall conform to the requirements of ASTM A 307. They shall be zinc-coated according to the requirement of AASHTO M 232, AASHTO M 298, Class 50, or ASTM B 633M (B 633) SC 3.

Stainless steel bolts shall conform to the requirements of ASTM A 193M (A 193), Class 1, Grade B 8M or B8. Stainless steel nuts shall conform to the requirements of AASHTO M 292, Grade 8 or 8F, and the washers shall conform to ASTM A 240, Type 302 or 304.

# 1006.30 Aluminum for Railings.

- (a) Cast Aluminum Railing Posts. Cast aluminum railing posts shall conform to the requirements of AASHTO M 193, Alloy A 444-T4.
- (b) Aluminum Alloy Extruded Rail. Aluminum alloy extruded rail shall conform to the requirements of ASTM B 221M (B 221), Alloy 6061-T6 or 6351-T5 with a minimum yield of 240 MPa (35,000 psi), a minimum tensile strength of 260 MPa (38,000 psi), and an elongation of 10 percent in 50 mm (2 inches).

#### 1006.31 Stainless Steel Hardware.

- (a) Stainless Steel Machine Bolts or Cap Screws. Stainless steel nuts, washers, lock washers, machine bolts or cap screws shall conform to the requirements of Article 1006.29(d).
- (b) Stainless Steel Bars. Stainless steel bars shall conform to the requirements of ASTM A 276, Type No. 302 or 304, Condition B. Threads, when required, shall be Class 2B.
- 1006.32 Stud Shear Connectors. Stud shear connectors shall conform to the requirements of AASHTO M 169 cold drawn bars, Grades 1015, 1018 or 1020, either semi- or fully-killed. Welding and workmanship shall be according to the requirements of the BWC.

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**1006.33** Seamless Copper Water Tube. Seamless copper water tube shall conform to the requirements of ASTM B 88M (B 88), Type K, except that the tolerance for wall thickness and mass/meter (weight per foot) shall be increased by 50 percent.

## 1006.34 Galvanized Steel for Railings.

- (a) Steel Posts for Railings. Steel posts shall conform to the requirements of AASHTO M 270, Grade 50, and shall be galvanized according to AASHTO M 111.
- (b) Tubular Steel Rail for Railings. Tubular steel rail shall conform to the requirements of ASTM A 500, Grade B, and shall be galvanized according to AASHTO M 111.

Tubular steel from all heats supplied shall be tested for impact toughness according to AASHTO T 266, "Charpy V-Notch (CVN) Impact Testing of Metallic Materials". The CVN impact requirements shall be 20 J (15 ft. lbs.) at -18 °C (0 °F.). For each heat supplied, the manufacturer shall furnish one 50 x 450 mm (2 x 18-inch) specimen, marked with its heat number, for impact testing.

In lieu of the above, the manufacturer may choose to supply tubing that has been tested for toughness according to ASTM E 436, "Standard Method for Drop-Weight Tear Tests of Ferritic Steels", as modified herein. Tubing test samples shall be taken and tested prior to delivery of the railing to the Contractor. The taking of the test samples shall be witnessed, and the testing shall be performed, by an approved independent testing laboratory.

Drop-weight tear testing shall be done on test specimens obtained from galvanized tubing with the same heat number as that being used. Testing shall be conducted at a temperature of -18  $^{\circ}$ C on 50 x 225 mm (0  $^{\circ}$ F. on 2" x 9") specimens supported to provide a 175 mm (7-inch) clear span. Galvanizing shall not be removed from the specimens. Three 50 x 225 mm (2" x 9") test specimens shall be cut from each of the unwelded sides for a total of nine specimens.

The three specimens from the side with the lowest average shear area shall be disregarded when calculating the final average shear area. The final average shear area shall then be calculated using the six remaining specimens. If the average shear area falls below 50 percent, material from the heat represented by these tests shall be rejected, except that if the average shear area is 30 percent or greater, one retest at a sampling frequency three times that of the first test, and with no samples excluded in calculating the average, will be permitted. Material not having a 50 percent average shear area upon retest shall be rejected. Certified test data shall be submitted with each shipment of railing.

No transverse welds will be permitted in the rail section.

The manufacturer of the tubing shall, before galvanizing, identify the product with the steel heat number (or with some number that is traceable to the heat number) and a unique manufacturer's identification code. The identification method shall be such that identification shall be on only one

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- face of the section, be repeated at intervals no greater than 1.2 m (4 ft), and not extend into the curved surface of the tubing at the corners.
- (c) Steel Shapes and Plates for Railing. Steel angles shall conform to the requirements of AASHTO M 270M, Grade 345 (M 270, Grade 50), and all other steel shapes and plates shall conform to the requirements of AASHTO M 270M, Grade 250 (M 270 Grade 36). This material shall be galvanized according to AASHTO M 111.
- (d) Storing on Site. In order to prevent rapid oxidation of the zinc coating, the Contractor shall protect all galvanized rail elements, splice sections, posts, and accessories from rain, snow, and other weathering conditions while they are stored on the site prior to installation. This protection shall consist of storing the galvanized parts of the railing off the ground surface so that they will not come in contact with surface run-off water and of properly covering the parts on the top and all sides. The Contractor shall use special care in storing this material so that no moisture gets between the pieces when they are stacked in contact with each other. When erected, the surfaces of the rail elements and posts shall have a uniform finish and shall not be tarnished, have mottled areas or a gritty appearance, nor show dip marks or brush marks. If "white rust" (zinc oxide) has formed on any of the surfaces of the rail elements, the affected material shall be rejected by the Engineer.

# **1006.35** Gabions and Slope Mattresses. The material shall conform to the following requirements:

- (a) Fabric. The baskets shall be constructed of a galvanized, aluminized, or PVC-coated galvanized or aluminized steel wire.
  - (1) Gabion baskets shall be constructed in a hexagonal mesh fabric with at least 3 half twists. The fabric opening shall have nominal dimensions of 82 mm x 115 mm (3.25 inch x 4.5 inch).
  - (2) Slope mattress baskets shall be constructed in a hexagonal mesh fabric with at least 3 half twists. The fabric opening shall have nominal dimensions of 60 mm x 82 mm (2.5 inch x 3.25 inch).
- (b) Wires for Selvedges, Lacing, and Internal Connections. All wires shall be of the same material and coating finish as the fabric.
- (c) Galvanized Steel Wire. The wire shall conform to the requirements of ASTM A 641M (A 641), Class 3, Soft.
- (d) Aluminized Steel Wire. The wire shall conform to the requirements of ASTM A 809, Soft.
- (e) PVC-Coated Galvanized or Aluminized Steel Wire. The PVC coating shall be applied to wire conforming to ASTM A 641M (A 641), Class 3, Soft, or ASTM A 809, Soft. The PVC shall be extruded and adhered (bonded), shall conform to the requirements of ASTM D 2287 and shall be 0.5 mm (± 0.127 mm) [0.020 inches (± .005 inch)]. The color of the PVC material shall be gray. The PVC coating shall be self-extinguishing and shall not support combustion when subject to the horizontal flame test of ASTM A 470.

(f) Wire Diameter. The minimum diameter of wires after coating for gabions and slope mattresses shall be according to the following tables:

GABIONS				
	Aluminized and Galvanized	PVC		
Fabric Wire	3 mm (0.118")	3.5 mm (0.136")		
Selvedge Wire	3.8 mm (0.150")	4.1 mm (0.163")		
Lacing and Internal Connecting Wires	2.2 mm (0.087")	3 mm (0.117")		

SLOPE MATTRESSES				
	Aluminized and Galvanized	PVC		
Fabric Wire	2.2 mm (0.087")	3.0 mm (0.117")		
Selvedge Wire	2.7 mm (0.106")	3.5 mm (0.136")		
Lacing and Internal Connecting Wires	2.2 mm (0.087")	3.0 mm (0.117")		

**1006.36 Wire Fasteners.** Wire fasteners shall be made of galvanized steel wire, aluminized steel wire or stainless steel wire. Galvanized wire fasteners shall be used on galvanized baskets, aluminized wire fasteners shall be used on aluminized baskets, and stainless steel wire fasteners shall be used on PVC coated baskets. Wire fasteners shall resist a force of at least 2700 N (600 lbs.) while remaining in a closed position when subjected to a directional tension force along any axis of the fastener.

- (a) Galvanized Steel Wire. Coating requirements shall conform to ASTM A 764, Type 3.
- (b) Aluminized Steel Wire. Coating requirements shall conform to ASTM A 809.
- (c) Stainless Steel Wire. The wire shall conform to ASTM A 313, 302 grade.

### 1006.37 Reserved.

### SECTION 1007. TIMBER AND PRESERVATIVE TREATMENT

**1007.01 Description.** This Specification covers structural timber for bridges and guardrail, timber piling, guard and guide posts, bracing stakes, woven wire fence posts and braces, and preservative treatment.

Inspection of both treated and untreated products except untreated native timber piling and the preservatives shall be performed by an independent agency engaged by the Contractor directly or through his/her supplier and approved by the Engineer. The cost of this inspection shall be included in the unit bid price. Acceptance for incorporation into a project will be based on an inspection report by an approved agency, showing compliance with the Specifications, and satisfactory results or any random inspection performed at the supplier's yard or the project site. Untreated native timber piling will be inspected at the source or at its destination by the Engineer.

- **1007.02 Definition of Terms.** The terms used shall be interpreted according to ASTM D 9.
- **1007.03 Structural Timber.** Only southern pine and Douglas fir (coast region) will be admitted for use as structural timber.
  - (a) Treated and Untreated Timber. When treated material is specified, the method of treatment shall be according to Article 1007.12. There shall be no heartwood requirements for timber which is to receive a preservative treatment and the amount of sapwood shall not be limited. All timber to be used without preservative treatment shall contain not less than 85 percent of heartwood measured on the girth.
  - (b) Standard Sizes and Grading Requirements. Rough cut and surfaced timber shall meet the applicable requirements for size and grading according to ASTM D 245 and the Southern Pine Inspection Bureau, or the West Coast Lumber Inspection Bureau except as provided herein.

All pieces shall be cut to length with square ends.

- **1007.04 Bridges.** Floor planks shall conform to the requirements provided for 1850 F dense southern pine or 1900 F dense Douglas fir. All other timber for bridges, except floor planks, shall conform to the requirements for 1600 F dense southern pine or 1700 F dense Douglas fir. The dimensions and surfacing requirements for all bridge timber will be shown in the contract.
- **1007.05 Wood Guardrail.** The posts, rails and other timber for wood guardrail shall comply with the requirements for No. 1 Dense SR 1550 F for southern pine or No. 1 Dense 1400 F for Douglas fir. The size and surfacing requirements for the timber will be shown in the contract.
- **1007.06** Steel Plate Beam Guardrail. The posts and other timber for steel plate beam guardrail shall comply with the requirements for No. 1 Dense SR 1550 F for southern pine or No. 1 Dense 1400 F for Douglas fir. The size and surfacing requirements will be shown in the contract.
- **1007.07** Cable Road Guard. The posts and other timber for cable road guard shall comply with requirements for No. 1 Dense SR 1550 F for southern pine or

No. 1 Dense 1400 F for Douglas fir. The size and surfacing requirements will be shown in the contract.

**1007.08 Piling.** Timber piling shall be treated or untreated.

(a) Untreated Timber Piling. When untreated timber piles are specified, they shall be any of the following species of woods which will satisfactorily withstand driving:

Cedar, Northern White
Cedar, Western Red
Chestnut

Pine, Southern
Pine, Norway
Cypress

Cypress

Elm, Rock Fir, Douglas (coast region)

Hickory Oak

(b) Creosoted Timber Piling. When creosoted timber piles are specified, they shall be:

> Pine, Southern Fir, Douglas (coast region) Oak, Red (commercial)

The method of treatment shall be according to Article 1007.12.

(c) Quality. All timber piles shall be cut from sound and solid trees. To avoid deterioration, they shall be cut within 12 months prior to use. The butt and tip shall be cut square with the axis of the pile. Piles shall be cut above the ground swell and shall taper from butt to tip. All knots and limbs shall be trimmed or cut flush with the surface of the pile.

The piles shall contain no unsound knots or knots in groups. Sound knots will be permitted provided the diameter of the knot does not exceed 100 mm (4 inches) or 1/3 of the diameter of the pile at the point where it occurs. The piles shall be free from twist of grain exceeding 1/2 the circumference in any 6 m (20 ft.) of length; shake more than 1/3 the diameter of the pile, or shake appearing on both ends of the pile; rot, incipient, or advanced decay; and season checks which penetrate more than 1/4 of the diameter of the pile or are more than 6 mm (1/4 inch) in width. Any defect or combination of defects, which will impair the strength of the pile more than the maximum knot, will not be permitted.

Untreated piles shall have all the outer bark removed. Piles to be treated shall be peeled by removing all the outer bark and at least 80 percent of the inner bark. No strip of inner bark remaining on the piles shall be over 20 mm (3/4-inch) wide and there shall be at least 25 mm (1 inch) of clean wood surface between any 2 such strips.

A line drawn from the center of the tip to the center of the butt shall not fall outside the center of the pile at any point more than one percent of the length of the pile. In short bends, the distance from the center of the pile to a line stretched from the center of the pile above the bend to the center of the pile below the bend shall not exceed 4 percent of the length of the bend, or 65 mm (2 1/2 inches). Piles shall be free from reverse bends.

(d) Dimensions. All measurements shall be made under the bark. Tip and butt measurements shall be as listed in the following table:

	DIAMETER - (mm)			
Length of Pile	Tip	900 mm From	Butt	
	Minimum	Butt Minimum	Maximum	
Less than 6 m	200	275	500	
6 m and less than 12 m	200	300	500	
12 m and less than 18 m	175	325	500	
18 m and more	150	325	500	

	DIAMETER - (inches)			
Length of Pile	Tip	3 Feet From	Butt	
	Minimum	Butt Minimum	Maximum	
Less than 20 feet	8	11	20	
20 and less than 40 feet	8	12	20	
40 and less than 60 feet	7	13	20	
60 feet and more	6	13	20	

**1007.09** Guard Posts and Guide Posts. The posts shall be of southern pine, Douglas fir, northern white cedar, redwood, green and white ash, American and slippery elm, black gum, or red oak.

- (a) Dimensions. The dimensions of the posts will be shown in the contract.
- (b) Quality. The posts shall be cut from sound and solid trees. They shall contain no unsound knots. Sound knots will be permitted, provided the diameter of the knot does not exceed 1/3 the diameter of the post at the point where it occurs. They shall be free from excess twist of grain; ring shake more than 1/3 the diameter of the post; and rot, incipient or advanced decay, except that in northern white cedar one pipe rot in the top of the post, and butt rot not to exceed 5 percent of the area of the butt will be permitted. Season checks which penetrate more than 1/4 the diameter of the posts at the point measured or which are more than 6 mm (1/4 inch) in width will not be permitted. The post shall be free from short or reverse bends. One-way sweep or crook will be permitted provided it does not exceed 50 mm (2 inches) measured at its maximum deviation.

**1007.10 Bracing Stakes.** Stakes for bracing trees and shrubs shall be of any species of wood which are durable and of sufficient strength to satisfactorily withstand driving.

- (a) Dimensions. For round stakes, the tip diameter shall be not less than 45 mm (1 3/4 inches) nor more than 63 mm (2 1/2 inches), and the butt diameter shall not exceed 75 mm (3 inches). Sawed stakes shall be not less than 45 mm (1 3/4 inches) nor more than 50 mm (2 inches) in width and thickness. The stakes shall be 2.5 m (8 ft.) in length; a variation of 50 mm (2 inches) will be permitted.
- (b) Quality. The stakes shall be cut from sound timber. They shall contain no

decayed knots, except that small pith knots will be permitted. The diameter of sound knots shall not exceed 1/2 the diameter of the stake at the point where they occur. They shall be free from excess twist of grain; excessive ring shake; and rot, except that in round stakes, pipe rot in the tip of the stakes which does not exceed 15 mm (1/2 inch) in diameter, and butt rot which does not exceed 5 percent of the area of the butt will be permitted. Season checks shall not penetrate more than 1/4 the diameter of the stake. The stakes shall be free from short or reverse bends. One-way sweep or crook will be permitted provided it does not exceed 75 mm (3 inches) measured at its maximum deviation. No more than 10 percent of the number of stakes in any lot shall contain the maximum crook or butt rot. The stakes shall be peeled of all outer bark, and all knots and branches shall be cut flush with the surface. The stakes shall be sharpened for driving and the opposite ends cut square.

**1007.11** Woven Wire Fence Posts and Braces. The posts and braces shall be of southern yellow pine or Douglas fir.

- (a) Dimensions. The dimensions of the posts and braces will be as shown in the contract. They may be either round or rectangular and if rectangular, they may be rough sawn or surfaced to standard dimensions.
- (b) Quality. The posts and braces shall have all the bark removed, knots and projections trimmed flush with the surface, shall be sound and free from decay, excessive twists of grain, unsound knots or knots in groups, or any structural defects. Knots in the posts shall not exceed 40 mm (1 1/2 inches) in size.

**1007.12 Preservative Treatment.** All products except piling may be inspected prior to treatment at the option of the Engineer. Timber piling shall be inspected prior to treatment and after for preservative retention. All products shall be inspected after treatment for any deviation from the requirements of the Specifications caused by the treating process.

- (a) Preservatives. The preservatives permitted shall be one of the following:
  - Creosote Oil. Creosote oil shall conform to the requirements of AWPA Standard P1.
  - (2) Pentachlorophenol. Pentachlorophenol shall be a mixture of not less than 5% pentachlorophenol and petroleum solvent. Pentachlorophenol shall conform to the requirements of AWPA Standard P8. Petroleum solvent shall be Type A and conform to the requirements of AWPA Standard P9.
  - (3) Water-Borne Preservative. Ammoniacal copper arsenate (ACA) shall conform to the requirements of AWPA Standard P5. Chromated copper arsenate (CCA) shall meet the requirements of AWPA Standard P5, Type A, Type B, or Type C.
- (b) Conditioning for Treatment. All timber products shall be seasoned before treatment as described in AWPA Standard C1. Since difficulty may be encountered in obtaining the specified retention and penetration, it is the responsibility of the treater to select timber for treatment that has sufficient sapwood thickness to permit penetration and retention as specified.

## Art. 1007.12 Timber and Preservative Treatment

Suitable conditioning and, for some species, incising prior to treatment, and the use of treating conditions that do not damage the wood according to AWPA Standard C1 and the AWPA Commodity Standards listed below are additional responsibilities of the treater.

- (c) Treating Process. Treatment with creosote oil or pentachlorophenol solution shall be by one of the empty-cell processes. Treatment with water-borne preservatives shall be by the full-cell process.
- (d) Special Treatment for Timber and Posts. Timber for wood guardrail, steel beam guardrail, cable road guard, guard posts, and guideposts which have been given oil preservative treatment, before being removed from the cylinder, shall be further subjected to live steam at a maximum pressure of 90 N (20 lbs.) and, following that, to an additional period of vacuum to ensure that the surface of the wood is free of accumulation of oil and tarry material.
- (e) Retention of Preservative. Retentions and preservatives permitted shall be according to AWPA Standard C1 and the AWPA Commodity Standards listed in the following table.

Preservative Retention Requirements kg per m <sup>3</sup>					
Product and Usage	Creosote	Penta- chlorophenol	ACA	CCA	AWPA Standard
Piles: Southern Pine Coastal Douglas Fir Oak	192.2	9.6	12.8	12.8	C3
	272.3	13.6	16.0	16.0	C3
	96.1	4.8	NA*	NA*	C3
Posts:  Guard, Guide, Sign, Fence and Braces Round Sawn Four Sides Guardrail and Spacer Blocks Round Sawn Four Sides	128.2	6.4	6.4	6.4	C14
	160.2	8.0	8.0	8.0	C14
	160.2	8.0	8.0	8.0	C14
	192.2	9.6	9.6	9.6	C14
Lumber:  For Bridges and Retaining Walls For Wood Guardrail  Miscellaneous Lumber for Human Contact: (Handrails, Picnic Tables, Etc.)	192.2	9.6	9.6	9.6	C14
	128.2	6.4	3.7	3.7	C14
In Contact with Ground or Water Not in Contact with Ground or Water	NA*	NA*	6.4	6.4	C2
	NA*	NA*	4.0	4.0	C2

<sup>\*</sup>Not allowed

# Preservative Retention Requirements Pounds Per Cubic Foot ENGLISH

Product and Usage	Creosote	Penta- chlorophenol	ACA	CCA	AWPA Standard
Piles:					
Southern Pine Coastal Douglas Fir Oak	12.0 17.0 6.0	0.60 0.85 0.30	0.80 1.00 NA*	0.80 1.00 NA*	C3 C3 C3
Posts:					
Guard, Guide, Sign, Fence and Braces Round Sawn Four Sides Guardrail and Spacer Blocks Round Sawn Four Sides	8.0 10.0 10.0 12.0	0.40 0.50 0.50 0.60	0.40 0.50 0.50 0.60	0.40 0.50 0.50 0.60	C14 C14 C14 C14
Lumber:					
For Bridges and Retaining Walls For Wood Guardrail	12.0 8.0	0.60 0.40	0.60 0.23	0.60 0.23	C14 C14
Miscellaneous Lumber for Human Contact: (Handrails, Picnic Tables, Etc.)					
In Contact with Ground or Water Not in Contact with Ground or Water	NA* NA*	NA* NA*	0.40 0.25	0.40 0.25	C2 C2

\*Not allowed

(f) Handling and Storage. Handling and storage of lumber items shall be as specified in AWPA Standard M4.

Treated material shall be placed in a position as to facilitate thorough drainage of any preservative remaining on the material. AWPA Standard M4 shall be used for repair of cuts and abrasions and treatment of bored holes. Three brush coats of the repair material shall be used. Each coat shall be allowed to dry before the next coat is applied. Treated material which is otherwise satisfactory may be rejected if coated with dirt. When material is stored for an extended length of time, the material shall be protected from the weather.

(g) Product Marking. Treated material shall be either hammer-or heat-branded, dye-stamped, or metal-tagged according to AWPA Standard M1 and M6, except that branding of piles shall be on the butt end. The charge number shall be included in the markings on all treated piles. Sawn materials 50 mm (2 inches) or less in nominal thickness that is treated with oil-type preservative may be bundled with tags being attached to the bundles. In lieu of bundle tags, when such materials are treated with water-borne preservative, the required information may be dye-stamped on the outer

pieces of the bundle.

(h) Inspection. All treated material shall be inspected according to AWPA Standard M2. Penetration and retention shall be determined by the assay method. Test reports listing test results shall accompany each shipment of treated material. The Department, at its option, may require a random check on preservative retention.

#### SECTION 1008, PAINT MATERIALS AND MIXED PAINTS

1008.01 General. All paint materials for use in the manufacture of these paints shall be delivered in the original packages and shall be used without adulteration. With the exception of aluminum paint, the paints shall be made by thoroughly dispersing the pigments in a portion of the vehicle and thinning with the remainder of the vehicle. The pigments shall be dispersed with an approved roller mill, pebble mill, ball mill or a high speed dispersion mill using a carborundum rotor and stator in such a manner that very little heat is developed. The dispersion of all pigments in the paints shall be such that the coarse particles and skins (total residue retained on a 45 μm (No. 325) sieve, based on pigment) will not exceed 1.5 percent. The quantities of paint materials and the quantities of pigment and vehicle used in formulating a paint shall be based on the average percentage of the minimum and maximum composition limits given in the Specifications. The manufacturer shall furnish to the Department the batch formula which will be used in manufacturing the paint. Paints shall be produced which during storage will not thicken, "skin over", liver, settle out appreciably, or cake badly in the containers, and which can be readily broken up with a paddle to a smooth, uniform consistency.

## 1008.02 Sampling, Testing and Inspection.

- (a) Plant Inspection. Before manufacture of any paint is started, the paint materials shall be set aside at the manufacturer's plant and will be sampled by an authorized representative of the Department. All materials represented by these samples shall be held until tests have been made and the materials found to comply with the requirements of the Specifications. All tests will be made by and at the expense of the Department. The Department also retains the option to waive inspection and testing of ingredient materials.
- (b) Color. Where the color requirements of a paint vehicle is specified in terms of "Hellige Comparator", it will be determined with a Hellige Comparator No. 605 using Permanent Glass Color Standards, Disks Nos. 620 C-40 and 620 C-42. These disks are equivalent to Gardner Color Standards 1933.

**1008.03 Packing.** Unless otherwise directed, the paints shall be shipped in 20 L (5-gal.) containers. Alluminum paint shall be shipped in double-compartment type containers. All containers shall be made of new metal not lighter than 0.607 mm (0.0239" 24 gage), may be either painted or galvanized, shall be of the same color and design for any one order, shall have lids of approximately the same diameter as the containers equipped with rubber gaskets, shall have bails with handles, and shall be so designed that they may be stacked one upon the other in tiers at least 4 high.

All containers shall meet the latest requirements of the U.S. Department of

Transportation for shipping paint.

The paints shall be measured by volume, the unit of measure being a liter (gallon) of 1000 cm<sup>3</sup> (231 cubic inches) at 25 °C (77 °F.). For the aluminum paint, the vehicle and the paste shall be packed separately in the containers in the proportions shown in the following table:

	Paste Type			
Quantity (Liter)	Vehicle (Liter) Paste (kgs			
20 4 2	16.26 3.25 1.63	3.90 0.78 0.39		

	Paste Type			
Quantity (Gal.)	Vehicle (Gal.)	Paste (Lbs.)		
5 1 1/2	4.296 0.859 0.430	8.59 1.72 0.86		

Each container shall bear a label which shows the kind of paint and the manufacturer's name. The lot number of the paint, and the month and year the paint is packaged shall be stenciled on the side of the container or included on the label.

#### **PIGMENTS**

- **1008.04** Leafing Aluminum Pigment. Leafing aluminum pigment shall be furnished in the paste form and shall conform to the requirements of ASTM D 962, Type II, Class B.
- **1008.05 Nonleafing Aluminum Pigment.** Nonleafing aluminum pigment shall be furnished in the paste form and shall conform to the requirements of ASTM D 962, Type 4, Class B medium.
- **1008.06 Carbon Black.** The pigment commercially known as carbon black shall be furnished in the dry form and shall conform to the requirements of ASTM D 561.
- **1008.07 Graphite.** The pigment commonly known as graphite, shall be purchased in the dry form.
  - (a) Manufacture. The pigment shall be made from natural crystalline flake graphite, amorphous graphite or crystalline graphite, mined or manufactured. It shall be high grade in every respect and shall be free from ground coal and powdered shale.
  - (b) Properties. The dry pigment shall conform to the following requirements:

Graphitic carbon, not less than	
Coarse particles retained on a	
45 μm (No. 325)	
sieve, not more than	. 2%

**1008.08 Lampblack.** The pigment commercially known as lampblack shall be furnished in the dry form or as a paste in oil and shall conform to the requirements of ASTM D 209.

- **1008.09 Magnesium Silicate.** The pigment commercially known as magnesium silicate shall be furnished in the dry form and shall conform to the requirements of ASTM D 605.
- **1008.10** Silica. The pigment commercially known as silica shall be purchased in the dry form.
  - (a) Manufacture. It shall be commercially pure silica, free from foreign material.
  - (b) Properties. The silica pigment shall have the clear, white color characteristic of this product. The dry pigment shall conform to the following requirements:

Silicon dioxide, not less than	98.0%
Moisture, not more than	1.0%
Coarse particles retained on a	
45 μm (No. 325)	
sieve, not more than	0.5%

#### **VEHICLES**

**1008.11 Bodied Linseed Oil.** The bodied linseed oil shall be pure linseed oil which has been heated to a temperature of 302 °C to 315 °C (575 °F. to 600 °F.) and held at this temperature until the necessary consistency has been obtained. It shall be clear, free from sediment or suspended matter, and shall conform to the following requirements:

Specific gravity at 15.6/15.6 °C (60/60 °F.)	
Saponification number	
lodine number (Wijs method), not less than	
Loss on heating at 105 °C to 110 °C (220 °F. to 230 °F.)	
not more than	0.2%
Viscosity (Gardner Holdt)	Z-2 to Z-5
Color: No darker than a standard sample furnished by the De	epartment.

- **1008.12 Boiled Linseed Oil.** Boiled linseed oil shall conform to the requirements of ASTM D 260, Type I.
- **1008.13** Raw Linseed Oil. Raw linseed oil shall be pure oil obtained from flax seed and shall conform to the requirements of ASTM D 234.
- **1008.14 Driers.** The driers shall be furnished as solutions of metallic salts and shall conform to the requirements of ASTM D 600, Class A, B, or C.

**1008.15 Petroleum Spirits.** Petroleum Spirits commercially known as "mineral spirits" shall consist only of petroleum distillates and shall conform to the requirements of ASTM D 235 Type I.

**1008.16 Turpentine.** Turpentine shall be "gum spirits" of turpentine and shall conform to the requirements of ASTM D 13.

**1008.17 Varnish.** (Phenolic Resin). This material shall be a long oil 100 percent phenolic resin varnish of maximum elasticity and durability, of a type suitable for exterior use with aluminum pigments, and shall be resistant to the effect of light, oil, and water. The oils used in the varnish shall be vegetable drying oils of a type necessary to meet the Specification requirements. The varnish shall conform to the following requirements:

Appearance: Clear and transparent.

Color: (Hellige Comparator), not darker than No. 18. Toughness: It shall pass a 120% Kauri reduction test.

Draft test: It shall pass the draft test.

"Skinning": The varnish shall show no "skinning" after 48 hours in a 3/4

filled, tightly closed container.

Cold water

resistance: A film of the varnish applied on a metal panel and air-dried for

72 hours, when submerged in cold water for 96 hours and then air-dried for one hour, shall show no whitening, dulling,

checking or other serious defects.

Hot water

resistance: A film of the varnish applied on a metal panel and air-dried for

72 hours, when submerged in boiling water for 6 hours and then air-dried for one hour, shall show no whitening, dulling,

checking, or other serious defects.

Working

properties: When thoroughly mixed with aluminum paste in the proportion

of 240 g/L (2 lbs. per gal.) of varnish, the paint shall have good leafing qualities, show satisfactory brushing and leveling properties, and shall not break or sag when applied to a

vertical, smooth, steel surface.

Drying time: When the varnish is applied to a metal panel and allowed to

dry in a vertical position, it shall set to touch in not less than 2 hours nor more than 6 hours and dry hard and tough in not

more than 24 hours.

**1008.18 Varnish (Spar).** The spar varnish shall be composed of heat treated linseed oil, china wood oil, perilla oil or prepared castor oil, or a mixture of these oils combined with ester gum or synthetic resins, or a mixture of ester gum and synthetic

## Art. 1008.18 Paint Materials and Mixed Paints

resins. It shall be suitable for exterior use with pigments, shall have resistance to oil, light and water, and shall conform to the following requirements:

Appearance: Clear and transparent.

Color: (Hellige Comparator), not darker than No. 18.

Working

properties: Shall have good brushing, flowing and leveling properties.

Cold water

resistance: A film of the varnish applied on a metal panel and air-dried for

24 hours, when submerged in cold water for 18 hours and then air-dried for 15 minutes, shall show no whitening or

dulling.

Hot water

resistance: A film of the varnish applied on a metal panel and air-dried for

24 hours, submerged in boiling water for 15 minutes and then air-dried for 15 minutes, shall show no whitening or dulling.

Toughness: It shall pass a 75 percent Kauri reduction test.

Draft test: The varnish shall pass the draft test.

Flash point (Tag closed tester), not less than	
Acid number, based on nonvolatile matter, not more than	
Viscosity (Gardner-Holdt)	
Set to touch, in not more than	
Dry hard and tough, in not more than	
g/L (lbs./gal.) @ 25 °C (77 °F.) min.,	875 (7.3)

#### MIXED PAINT

**1008.19 Aluminum Paint.** The aluminum paint shall be composed of aluminum paste and phenolic resin varnish.

The aluminum paint shall be mixed at the site of the work. When aluminum paint is to be used for the final field coat, only enough for one day's use shall be mixed at a time.

- (a) Materials. The aluminum paste shall meet the requirements of Article 1008.04, and the phenolic resin varnish of Article 1008.17.
- (b) Formula. The paint shall be formulated as follows:

Aluminum paste	907	g (2	lbs.)
Varnish (Phenolic Resin)	4	Ĺ (1	gal.)

(c) Properties. When the paint is applied to a metal panel and allowed to dry in a vertical position, it shall set to touch in not more than 6 hours, and dry hard and tough in not more than 24 hours. The paint shall be of such consistency that it will have satisfactory spreading, leveling and "leafing" qualities, and shall not break or sag when applied to a smooth, vertical surface.

**1008.20 Nonleafing Aluminum Paint.** The nonleafing aluminum paint shall be composed of nonleafing aluminum paste and phenolic resin varnish.

The nonleafing aluminum paint shall be mixed at the site of the work.

- (a) Materials. The nonleafing aluminum paste shall meet the requirements of Article 1008.05, and the phenolic resin varnish shall meet the requirements of Article 1008.17.
- (b) Formula. The paint shall be formulated as follows:

Nonleafing aluminum paste9	07	g (2	lbs.)
Varnish	4	Ĺ (1	gal.)

- (c) Properties. When the paint is applied to a metal panel and allowed to dry in a vertical position, it shall set to touch in not more than 6 hours, and dry hard and tough in not more than 24 hours. The paint shall be of such consistency that it will have satisfactory spreading and leveling qualities and shall not break or sag when applied to a smooth, vertical surface. The paint shall be nonleafing.
- **1008.21 Black Graphite Paint.** The black graphite paint shall be composed of graphite, carbon black, magnesium silicate, silica, raw linseed oil, bodied linseed oil, petroleum spirits, and drier.
  - (a) Materials. The graphite shall meet the requirements of Article 1008.07, the carbon black of Article 1008.06, the magnesium silicate of Article 1008.09, the silica of Article 1008.10, the raw linseed oil of Article 1008.13, the bodied linseed oil of Article 1008.11, the petroleum spirits of Article 1008.15 and the drier of Article 1008.14.
  - (b) Composition. The paint shall have the following composition by weight:

Pigment:

Graphite	54 to 56%
Carbon black	
Magnesium silicate	28 to 30%
Silica	10 to 12%
Vehicle:	
Raw linseed oil	48 to 50%
Bodied linseed oil	
Petroleum spirits and drier	36 to 38%
Paint:	
Pigment	36 to 38%
Vehicle	62 to 64%
Moisture, if present not more than	1.0%

(c) Properties. The mass (weight) per liter (gallon) of the paint at 25 °C (77 °F.) shall be not less than 1.13 kg (9.4 lbs.). The paint shall be of such consistency that it will have satisfactory spreading and leveling qualities, and when applied to a smooth, vertical steel panel shall dry within 18 hours to a hard, smooth film without running, streaking or sagging.

**1008.22 Inorganic Zinc-Rich Primer.** This specification covers a solvent-base, multiple component, self curing alkyl silicate zinc-rich paint which cures without use of a separate curing solution. It is intended for use only on blast-cleaned steel and for spray application. Limited application by brush can be made.

The inorganic zinc-rich primer shall meet the requirements of AASHTO M300 Type I with the following additional requirement: The Volatile Organic Compounds (VOC) shall not exceed 340 g/L (2.8 lb./gal.) for both shop and field painting as applied when tested in accordance with ASTM D3960.

- (a) Qualification Samples and Tests. The manufacturer shall supply to an independent test laboratory and to the Department, duplicate samples of the inorganic zinc-rich primer for evaluation. Prior to approval and use, the manufacturer shall submit a notarized certification of the independent laboratory, together with results of all tests, stating that this material meets the requirements as set forth herein. The certified test report shall state lot tested, manufacturer's name, product name, and date of manufacture. New certified tests results and samples for testing by the Department shall be submitted anytime the manufacturing process or paint formulation is changed. All costs of testing (other than tests conducted by the Department) shall be borne by the manufacturer.
- (b) Acceptance Samples and Certification. A 1 liter (1 quart) sample of each lot of paint produced for use on State or local agency projects shall be submitted to the Department for testing, together with a manufacturer's certification. The certification shall state that the formulation for the lot represented is essentially identical to that used for qualification testing. All acceptance samples shall be taken by a representative of the Illinois Department of Transportation. The inorganic zinc-rich primer shall not be used until tests are completed and they have met the requirements as set forth herein.
- **1008.23 White Titanium Paint.** The white titanium paint and the pigments therein shall conform with the requirements of AASHTO M 70-85, Type 1.

#### **SECTION 1009. BITUMINOUS MATERIALS**

- **1009.01 Description.** Bituminous materials shall include asphalt cements, asphalt fillers, emulsified asphalts, rapid curing liquid asphalts, medium curing liquid asphalts, slow curing liquid asphalts, and road oils. All bituminous materials used in a given construction shall be uniform in character, appearance and consistency.
- **1009.02 Sources of Supply.** All sources of supply shall be approved by the Engineer before delivery is started. If sources previously accepted are found to be unacceptable to the Engineer, the Contractor will be required to furnish materials from other approved sources.

The Contractor shall submit to the Engineer a statement giving the sources of the bituminous materials he/she proposes to use. Only bituminous materials from these sources shall be used on the work unless approval, in writing, is obtained from the Engineer.

**1009.03 Measurement of Volume.** Measurement of the volume of asphalt cements, asphalt fillers, emulsified asphalts, rapid curing liquid asphalts, medium curing liquid asphalts, slow curing liquid asphalts and road oils will be based on the volume of the material at 15.6 °C (60 °F.). Volumes measured at higher or lower temperatures will be corrected to the volume at 15.6 °C (60 °F.), using the Standard ASTM-IP Petroleum Measurement Tables, ASTM D 1250.

Payment will not be made for bituminous materials in excess of 105 percent of the amount specified by the Engineer.

If bituminous materials are delivered by tank truck from a refinery or from a storage tank, a weight ticket for each truck load shall be furnished the Inspector. It shall show the weight of the empty truck (the truck being weighed each time before it is loaded), the weight of the loaded truck, and the net weight of the bituminous material. If the material is being paid for by the liter (gallon), the specific gravity at 15.6 °C/15.6 °C (60 °F./60 °F.) of the bituminous material in the tank truck and the number of liters (gallons) at 15.6 °C (60 °F.) shall be shown on the weight ticket. The scales shall be approved by the Engineer.

**1009.04 Delivery.** When bituminous materials are not approved at the source by the Department, they shall be delivered far enough in advance of their use on the work to permit the necessary tests to be made. When not delivered in tank cars or tank trucks, the bituminous materials shall be delivered in suitable containers or packages, plainly labeled to show the kind of material, the name of manufacturer, and the lot or batch number. Each shipment and each carload shall be kept separate until the material has been accepted.

Asphalt cement when delivered in tank cars or tank trucks, shall be delivered at a temperature not to exceed 175  $^{\circ}$ C (350  $^{\circ}$ F.).

Petroleum Asphalts PAF-1 and PAF-2 shall be shipped in new, double end, metal drums. The thickness of the metal used shall not be less than 0.4 mm (0.0149 inch). The side seams of the drums shall be double lapped, spot welded single lapped, or stitch welded single lapped. The seams shall meet the approval of the Engineer. The drums shall be manufactured so that there will be no leakage during hot weather. The capacity of each drum shall be approximately 210 kg (460 lbs.), the drums being 890 mm (35 inches) maximum in height and approximately 560 mm (22 inches) in diameter.

Petroleum Asphalts PAF-3 and PAF-4 shall be shipped in new, open end, metal drums. The thickness of the metal used shall be not less than 0.4 mm (0.0149 inch). The seams shall be constructed so that the filled drums will withstand shipping and handling. The inside of the drums shall be coated with talc or other approved material to facilitate peeling. The capacity of each drum shall be approximately 210 kg (460 lbs.), the drums being 890 mm (35 inches) maximum in height and approximately 560 mm (22 inches) in diameter. Petroleum Asphalts PAF-3 and PAF-4 may, when specified, be shipped in approved 45 kg (100 lbs.) cartons.



**1009.05 Asphalt Cement (Prepared from Petroleum).** These materials shall be free from water and shall not foam when heated to any temperature below the actual flash point. They shall conform to the requirements listed in the following table:



## REQUIREMENTS FOR ASPHALT CEMENT GRADED BY VISCOSITY AT 60 °C (140 °F.) (Grading based on Original Asphalt)

		Viscosity Grade					
TEST	AC-2.5	AC-2.5 AC-5 AC-10 AC-20			AC-40		
Viscosity 60 °C Pascal Seconds Viscosity	25±5	50±10	100±20	200±40	400±80		
135 °C mm²/S -minimum	125	150	225	300	400		
Penetration 25 °C 100 g., 5 sec-min.	175	120	75	50	40		
Flash Point, COC: °C-minimum	177	204	232	232	232		
Solubility in trichloroethylene, %-minimum	99.0	99.0	99.0	99.0	99.0		
Tests on Residue from Thin Film Oven Test:							
Viscosity 60 °C Pascals Seconds	100	200	400	800	1600		
Ductility 25 °C 5 cm per min.,							
cm-min.	100 <sup>1/</sup>	100	75	50	25		

<sup>1/</sup> If ductility is less than 100, the material will be acceptable if the ductility is 100+ at 15.6  $^{\circ}\text{C}$  (60  $^{\circ}\text{F.}).$ 

The different grades are, in general, used for the following:

AC-2.5 & AC-5	-	For surface treatment and
		stabilized sub-base.

(Class B) and bituminous base course.

AC-10 & AC-20 - For bituminous concrete base course

(high volume), Class I Bituminous Concrete binder and surface course, and full depth

bituminous pavement.

AC-40 - When specified.

AC-2.5, AC-5, - For Class I, Type 2, the Engineer reserves the right to specify the grade which shall be used.

AC-20 - Class I, Type 1.

When requested, producers shall provide the Engineer with viscosity/temperature relationships for the viscosity graded asphalt cements delivered and incorporated in the work.

**1009.06** Asphalt Fillers (Prepared from Petroleum). These materials shall be free from water and shall not foam when heated to the flash point. They shall conform to the requirements listed in the following table:

	Grades			
Test	PAF-1	PAF-2	PAF-3	PAF-4
Flash point (Cleveland open cup), °C Softening point (ring and ball method), °C Penetration at 0 °C, 200g, 60 sec Penetration at 25 °C, 100g, 5 sec Penetration at 45 °C, 50g, 5 sec Loss on heating at 163 °C, 50 g, 5 hrs., percent Penetration at 25 °C, 100 g., 5 sec., of asphalt after heating at 163 °C, as compared with penetration of asphalt before heating, percent Ductility at 25 °C, cm Bitumen soluble in trichloroethylene, percent	232+ 50+ 30+ 80 to 100  1.0- 70.0+ 40+ 99.0 +	232+ 57+ 15+ 40 to 55 190- 1.0- 70.0+ 15+ 99.0+	232+ 75 to 85 10+ 25 to 40 90- 1.0- 70.0+ 2.5+ 99.0+	246+ 82+ 15+ 30 to 50 80- 1.0- 70.0+ 2.5+ 99.0+

	Grades			
Test (English Units)	PAF-1	PAF-2	PAF-3	PAF-4
Flash point (Cleveland open cup), °F Softening point (ring and ball method), °F Penetration at 32 °F., 200g, 60 sec Penetration at 77 °F., 100g, 5 sec Penetration at 115 °F., 50g, 5 sec Loss on heating at 325 °F., 50 g, 5 hrs., percent Penetration at 77 °F., 100 g., 5 sec., of asphalt after heating at 325 °F., as compared with penetration of asphalt before heating, percent Ductility at 77 °F., cm Bitumen soluble in trichloroethylene, percent		15+	450+ 167 to 185 10+ 25 to 40 90- 1.0- 70.0+ 2.5+ 99.0+	475+ 180+ 15+ 30 to 50 80- 1.0- 70.0+ 2.5+ 99.0+

The different grades are, in general, used for the following:

PAF-1 & PAF-2 - For filling cracks in portland cement

concrete pavement.

PAF-3 - For sealing expansion and contraction joints

in portland cement concrete pavement

and for undersealing portland cement concrete pavement.

PAF-4 - For sealing expansion and contraction joints in

portland cement concrete pavement and

for filler in brick pavement.



**1009.07 Emulsified Asphalts.** These materials shall be homogeneous and shall show no separation of asphalt after thorough mixing, within 30 days after delivery, provided separation has not been caused by freezing. They shall coat the aggregate being used in the work to the satisfaction of the Engineer and shall conform to the following requirements:

- (a) Anionic Emulsified Asphalt. Anionic emulsified asphalts shall conform with the requirements of AASHTO M 140.
- (b) Cationic Emulsified Asphalt. Cationic emulsified asphalts shall conform with the requirements of AASHTO M 208.
- (c) High Float Emulsion. High float emulsion shall meet the requirements listed in the following table:

HIGH FLOAT EMULSION					
Me	dium Settir	ng			
TEST	HFE-60	HFE-90	HFE-150	HFE-300	
Viscosity, Saybolt Furol, at 50 °C (122 °F.), sec	50+*	50+*	50+*	50+*	
Sieve test (850 μm) (No. 20), retained on sieve, percent	0.10-	0.10-	0.10-	0.10-	
Settlement, percent 1/	5-	5-	5-	5-	
Storage Stability test, 1 day <sup>2/</sup>	1-	1-	1-	1-	
Distillation test:  Residue from distillation test to 260 °C (500 °F.), percent Oil distillate, by volume percent	65+ 7-	65+ 7-	65+ 7-	65+ 7-	
Characteristics of residue from distillation Test to 260 °C (500 °F.), Penetration at 25 °C (77 °F.), 100 g, 5 sec	60-90	90-150	150-300	300+	
Coating test (All Grades)	3 minutes , stone coated thoroughly				
Float test at 60 °C (140 °F.), sec	1200+	1200+	1200+	1200+	

## \* And Pumpable

- 1/ The test requirement for settlement may be waived when the emulsified asphalt is used in less than 5 days time; or the purchaser may require that the settlement test be run from the time the sample is received until it is used, if the elapsed time is less than 5 days.
- 2/ The 24-hour (1-day) storage stability test may be used instead of the 5-day settlement test.
  - (d) Penetrating Emulsified Prime (PEP). The penetrating emulsified prime shall meet the following requirements when tested according to AASHTO T59:

Viscosity, Saybolt Furol, at 25 °C (77 °F.), max. seconds	75
Sieve test, retained on 850 µm (No. 20) sieve, max. percent	
Distillation to 260 °C (500 °F.)Residue, min. percent	38
Oil distillate by volume, max, percent	

In addition, the PEP shall pass the following sand penetration test:

The standard reference sand for this test shall be a natural silica type, composed almost entirely of naturally rounded grains of nearly pure quartz, and shall be graded as follows:

#### Bituminous Materials

Sieve	180 μm	150 μm	106 μm	75 μm
	(No. 80)	(No. 100)	(No. 140)	(No. 200)
Percent Passing	99±1	97±3	50±5	2±2

Dampen 312.5 g of reference sand with 5.0 g of water. Place the moistened sand into a cylindrical metal container having a nominal capacity of 235 ml (8 oz.), and compress at 690 kPa (100 psi). Measure 5 grams of prime into the container of compacted sand and record the time for penetration in seconds. Remove a cross section of the sand and record the depth of penetration in millimeters. The time of penetration shall be equal to or less than that of MC-30. The depth of penetration shall be equal to or greater than that of MC-30.

(e) Latex Modified Emulsified Asphalt. The 100% natural latex modifier added at a minimum of 2.5% natural rubber solid by weight of binder (asphalt & rubber) and other emulsifiers shall be milled into the asphalt cement and shall show no separation after mixing. The latex modified CSS-1h Emulsified Asphalt shall meet the following requirements:

Viscosity, Saybolt Furol at 25 °C (77 °F.), seconds15-100
Storage stability test, 24 hours, percent maximum1
Particle charge testpositive
Sieve test, percent, maximum0.10
*Distillation residue, percent minimum62
Tests on residue from distillation:
Penetration, 25 °C (77 °F.), 100 grams, 5 seconds40-80
Ductility, 25 °C (77 °F.), 5 cm/min, cm, minimum50
Solubility in trichloroethylene, percent, minimum97.5
Softening point, °C (°F.), minimum60 (140)
Viscosity, 60 °C (140 °F.), Pa·s (poises), minimum 800 (8000)

<sup>\*</sup>The distillation for latex modified emulsion shall be performed according to AASHTO T-59 except the temperature shall be changed from 260  $\pm$  5 °C (500  $\pm$  9 °F.) to 175  $\pm$  5 °C (347  $\pm$  9 °F.).

The different grades are, in general, used for the following:

SS-1, SS-1h, CSS-1,

CSS-1h, HFE 60, HFE 90 For tack or fog seal.

PEP For bituminous surface treatment prime.

RS-1, RS-2, CRS-1,

CRS-2, HFE 90, HFE 150,

HFE 300 For bituminous surface treatment.

MS-1, MS-2, SS-1, CMS-1, CMS-2, CSS-1,

HFE 150, HFE 300 For coarse graded aggregate mixes.

MS-2, HFE 90, HFE 150,

HFE 300 For machine mix surfaces, open graded

aggregate mixes.

SS-1, HFE 300 For fine graded aggregate mixes.

SS-1, SS-1h, CSS-1,

CSS-1h For asphalt coated mulch.

Latex Modified For microsurfacing.



**1009.08** Rapid Curing Liquid Asphalts. These materials shall be rapid curing cut-back asphalts consisting of a petroleum residuum fluxed with a suitable distillate. They shall be free from water, show no separation on standing, and shall conform to the requirements listed in the following table:

	GRADES				
Test	RC-70	RC-250	RC-800	RC-3000	
Flash point (Tag open cup), °F. Flash point (Tag open cup), °C Viscosity, Kinematic,		80+ 27+	80+ 27+	80+ 27+	
at 60 °C (140 °F.), mm <sup>2</sup> /sec (cSt)	70 to 140	250 to 500	800 to 1600	3000 to 6000	
Distillation test: Distillate, percent by volume of total distillate 360 °C (680 °F.) Distillate to 190 °C (374 °F.) Distillate to 225 °C (437 °F.) Distillate to 260 °C (500 °F.) Distillate to 315 °C (600 °F.) Residue from distillation to 360 °C (680 °F.), Percent volume by difference	10+ 50+ 70+ 85+	35+ 60+ 80+	 15+ 45+ 75+	  25+ 70+	
Tests on residue from distillation: Penetration at 25 °C (77 °F.), 100 g, 5 sec Ductility at 25 °C (77 °F.), cm/2 Bitumen soluble in trichloroethylene, percent	80 to 120 100+ 99.5+	80 to 120 100+ 99.5+	80 to 120 100+ 99.5+	80 to 120 100+ 99.5	



**1009.09 Medium Curing Liquid Asphalts.** These materials shall be medium curing cut-back asphalts consisting of a petroleum residuum fluxed with a suitable distillate. They shall be free from water, show no separation on standing, and shall conform to the requirements listed in the following table:

	Grades				
Test	MC-30	MC-70	MC-250	MC-800	MC-3000
Flash point (Tag open cup), °C 1/ Flash point (Cleveland open cup), °C Viscosity, Kinematic, at 60 °C, mm2/sec. Distillation test Distillate, percent by volume of total distillate to 360 °C Distillate to 225 °C Distillate to 260 °C Distillate to 315 °C Residue from distillation to 360 °C, percent volume by difference Tests on residue from distillation Penetration at 25 °C, 100 g, 5 sec Ductility at 25 °C, cm 2/  Bitumen soluble in trichloroethylene, percent	38+  30 to 60 25- 40 to 70 75 to 93 50+ 120 to 250 100+ 99.5+	38+  70 to 140 20- 20 to 60 70 to 90 55+ 120 to 250 100+ 99.5+	 65+ 250 to 500 10- 15 to 55 60 to 87 67+ 120 to 250 100+ 99.5+	 65+ 800 to 1600  35- 45 to 80 75+ 120 to 250 100+ 99.5+	 65+ 3000 to 6000  15- 15 to 75 80+ 120 to 250 100+ 99.5+

	Grades				
Test	MC-30	MC-70	MC-250	MC-800	MC-3000
Flash point (Tag open cup), °F.1/ Flash point (Cleveland open cup), °F. Viscosity, Kinematic, at 140 °F., cSt Distillation test Distillate, percent by volume of total distillate to 680 °F. Distillate to 437 °F. Distillate to 500 °F. Distillate to 600 °F. Residue from distillation to 680 °F., percent volume by difference Tests on residue from distillation Penetration at 77 °F., 100 g, 5 sec Ductility at 77 °F., cm 2/  Bitumen soluble in trichloroethylene, percent	100+ 30 to 60  25- 40 to 70 75 to 93  50+  120 to 250  100+  99.5+	100+ 70 to 140  20- 20 to 60 70 to 90  55+  120 to 250  100+  99.5+	150+ 250 to 500 10- 15 to 55 60 to 87 67+ 120 to 250 100+ 99.5+	150+ 800to 1600  35- 45 to 80 75+ 120 to 250 100+ 99.5+	150+ 3000 to 6000  15- 15 to 75 80+ 120 to 250 100+ 99.5+

- 1/ Flash point by Cleveland open cup may be used for products having a Flash Point greater than 80  $^{\circ}$ C (175  $^{\circ}$ F.)
- 2/ If ductility is less than 100, the material will be acceptable if the ductility is 100 + at 15  $^{\circ}C$  (60  $^{\circ}F.).$

#### Bituminous Materials

The different grades are, in general, used for the following:

MC-30 and MC-70 - For prime coats.

MC-250 - For road mix surfaces dense-graded

aggregate type.

MC-800 - For traveling plant mix surfaces

dense-graded aggregate type, for surface

treatment and for seal coat.

MC-3000 - For modified plant mix surfaces

dense-graded aggregate type, for surface

treatment and for seal coat.



**1009.10 Slow Curing Liquid Asphalts.** These materials shall be slow curing liquid asphalts produced by the distillation of petroleum. The liquid asphalts shall be residues, distillates or residues fluxed to the desired consistency with petroleum distillates. Each shipment of liquid asphalt shall be uniform in appearance and consistency. All grades shall be free from water and shall not foam when heated to 107 °C (225 °F.) The residues of specified penetration shall be smooth and homogeneous in appearance. These materials shall conform to the requirements listed in the following table:

	Grades					
Test	SC-70	SC-250	SC-800	SC-3000		
Flash point (Cleveland open cup), °C Viscosity, Kinematic, at 60 °C, mm2/sec. Residue of 100 penetration, percent Ductility at 25 °C, of residue of specified	65+ 70 to 140 50+	80+ 250 to 500 60+	93+ 800 to 1600 70+	107+ 3000 to 6000 80+		
penetration, cm Loss on heating at 163 °C, 50 g, 5 hours,		100+	100+	100+		
percent Bitumen soluble in trichloroethylene, percent	99.0+	8- 99.0+	5- 99.5+	4- 99.5+		

	Grades					
Test	SC-70	SC-250	SC-800	SC-3000		
Flash point (Cleveland open cup), ±F. Viscosity, Kinematic, at 140 ±F., cSt Residue of 100 penetration, percent Ductility at 77 ±F., of residue of specified	150+ 70 to 140 50+	175+ 250 to 500 60+	200+ 800 to 1600 70+	225+ 3000 to 6000 80+		
penetration, cm Loss on heating at 325 ±F., 50 g, 5 hours,	100+	100+	100+	100+		
percent Bitumen soluble in trichloroethylene,	11-	8-	5-	4-		
percent	99.0+	99.0+	99.5+	99.5+		

The different grades are, in general, used for the following:

SC-70 - For dust layer and for prime coats.

SC-250 - For road mix and traveling plant mix surfaces dense-graded aggregate type.

SC-800 - For plant mix surfaces dense-graded aggregate type.

SC-3000 - For plant mix surfaces dense-graded aggregate type, for surface treatment, and for seal coat.



**1009.11 Road Oils.** (For surface treatment of earth roads.) These materials shall be slow curing asphaltic oils. They shall show no separation on standing and shall conform to the requirements listed in the following table:

		Grades	
Test	E-2	E-3	E-4
	Light	Medium	Heavy
Water, by volume, percent Flash Point (Cleveland open cup) °C Flash Point (Cleveland open cup) (°F.)  Viscosity, Kinematic, at 50 °C (122 °F.) mm2/sec. (cSt).	0.5-	0.5-	0.5-
	93+	93+	93+
	(200+)	(200+)	(200+)
Viscosity, Saybolt Furol, at 50 °C (122 °F.), sec Bitumen soluble in trichloroethylene, percent Residue of 100 penetration, percent Ductility at 25 °C (77 °F.), of residue of specified penetration, cm		135 to 240	

Art. 1010.01 Fly Ash

#### **SECTION 1010. FLY ASH**

**1010.01 Description.** Fly ash shall consist of the finely divided residue that results from the combustion of ground or powdered coal, transported from the combustion chamber by exhaust gas, collected by mechanical or electrical means, and stored in stockpiles or bins.

**1010.02 Pozzolanic Mixtures (Lime-Fly Ash or Cement-Fly Ash).** The fly ash shall meet the requirements of AASHTO M 295, Class C, or Class F, except that if dampened for the purpose of transportation, the loss-on-ignition shall not exceed 10 percent. The fly ash when dry sieved shall meet the following gradation:

<u>Sieve</u>	Minimum Percent Passing
12.5 mm (1/2 inch)	100%
9.5 mm (3/8 inch)	95%
2.00 mm (No.10)	75%

Fly ash moisture content shall not exceed 35 percent.

1010.03 Portland Cement Concrete and Cement Aggregate Mixture II. The fly ash used shall meet the requirements of AASHTO M 295, Class C or F, except a limitation of available alkalies, as  $NA_2O$ , of 1.5%, shall apply to fly ashes used in portland cement concrete mixtures and cement aggregate mixture II containing alkali-sensitive aggregates or admixtures. The Department's Policy Memorandum entitled "Acceptance Procedures for Fly Ash for Use in Portland Cement Concrete" will be used to determine a list of approved sources, and it shall be the Contractor's responsibility to determine the acceptability of fly ash prior to its incorporation in the work. The Department may suspend source approval at any time, upon written notice to the Contractor, if its random quality assurance sampling and testing indicate noncompliance with these requirements. Different sources or types of fly ash shall not be mixed or used alternately in the same item of construction unless authorized by the Engineer.

**1010.04 Mineral Filler in Bituminous Mixtures.** The fly ash shall meet the requirements of AASHTO M 295, Class C, or Class F except if dampened for the purpose of transportation, the loss-on-ignition shall not exceed 12 percent.

## **SECTION 1011. MINERAL FILLER**

**1011.01 Description.** Mineral filler shall consist of dry limestone dust, or other material approved by the Engineer, conforming to the following requirements:

Passing	$600 \mu m$	(No.	30)	sieve	100%
Passing	150 μm	(No.	100)	sieve	$92 \pm 8\%$
Passing	75 um	(No.	200)	sieve	82 ± 18%

The source of supply shall be approved by the Engineer. When mineral filler is used in bituminous concrete, the Contractor shall submit to the Engineer a statement giving the source of the mineral filler. Only mineral filler from this source shall be used on the job unless approval in writing is obtained from the Engineer.

Art. 1012.01 Lime

### **SECTION 1012. LIME**

1012.01 Hydrated Lime. Hydrated lime shall conform to the requirements of ASTM C 207, Type N. When used in pozzolanic aggregate mixture, the following modifications to ASTM C 207 shall apply:

(a)	Total calcium and magnesium oxides (nonvolatile basis) min. percent $\dots$ 90
(b)	Calcium oxide in hydrated lime (as received basis) max. percent 5
(c)	Magnesium hydroxide (as received basis) max. percent 5
(d)	Mechanical moisture in hydrated lime (as received basis) max. percent $\dots$ 4

(e) Residue - The sieve analysis of the lime residue shall be as follows:

(a) Total calcium and magnesium evides

<u>Sieve</u>	Maximum Percent Retained
4.75 mm (No. 4) 600 μm (No. 30)	0 2.5
150 μm (No. 100)	15

1012.02 Hydrated By-Product Lime. Hydrated by-product lime shall conform to the following requirements:

(a)	(nonvolatile basis) min. percent	65
(b)	Available Calcium hydroxide (rapid sugar test,	

Percent available  $Ca(OH)_2 + (\%MgO) (1.828) =$  percent equivalent available  $Ca(OH)_2$ . Where the available Ca(OH)<sub>2</sub> is above the minimum indicating high calcium lime, determination of the MgO is not necessary.

(c) Loss on ignition (carbon dioxide plus moisture, combined and free) on as-received basis.

ASTM C 25) plus total MgO content calculated to be

(e) Residue. The sieve analysis of the hydrated by-product lime shall be as follows:

<u>Sieve</u>	Maximum Percent Retained
4.75 mm (No. 4)	0
600 μm (No. 30)	2.5
150 μm (No. 100)	15

**1012.03** By-Product Lime for Lime Modified Soils. When used in lime modified soils, by-product lime (kiln dust) shall be either hydrated or non-hydrated conforming to the following requirements:

(a)	Total calcium and magnesium oxides (nonvolatile basis) min. percent 60						
(b)	(b) Available calcium hydroxide (rapid sugar test, ASTM C 25) plus total MgO content calculated to be equivalent Ca(OH) <sub>2</sub> min. percent						
(c)	<ul> <li>As received loss on ignition (carbon dioxide moisture, combined and free), max. percent</li> </ul>						
(d)	) Free Water (as-received bases), max. perceived	ent 4					
(e)	) Residue - The sieve analysis of the by-prod	luct lime shall be as follows:					
	<u>Sieve</u> <u>Maxim</u>	num Percent Retained					
	4.75 mm (No. 4) 600 μm (No. 30) 150 μm (No. 100)	5 10 25					
When us following	<b>Non-Hydrated By-Product Lime for</b> used in lime stabilized soil mixture, non-hydrateng requirements:  ) Total calcium oxides (nonvolatile basis) min	ed by-product lime shall meet the					
(b)	) Available calcium hydroxide (rapid sugar tes as determined by ASTM C 25), min percent	•					
(c)	<ul> <li>Loss on ignition (carbon dioxide plus moistu combined and free on as-received basis), m</li> </ul>						
(d)	) Free Water (as-received bases), max. perce	ent 2					

<u>Sieve</u>	Maximum Percent Retained
4.75 mm (No. 4)	5
600 μm (No. 30)	10
150 μm (No. 100)	25

(e) Residue - The sieve analysis of the by-product lime shall be as follows:

# **SECTION 1013. CHLORIDES**

**1013.01 Calcium Chloride.** Calcium chloride shall conform to the requirements of AASHTO M 144.

**1013.02 Sodium Chloride.** Sodium chloride shall conform to the requirements of AASHTO M 143, Type 1, Grade 1, except that the sodium chloride (NaCl) content shall be a minimum of 96.0%.

### PORTLAND CEMENT CONCRETE ITEMS

### SECTION 1020. PORTLAND CEMENT CONCRETE

**1020.01 Description.** This item shall consist of the materials, proportioning, mixing, transporting, curing and protecting portland cement concrete.

**1020.02 Materials.** Materials shall meet the requirements of the following Articles of Section 1000 - Materials:

	Item	Article/Section
(a)	Portland Cement	1001
(b)	Water	1002
(c)	Fine Aggregate	. 1003.01 - 1003.02
(d)	Coarse Aggregate	. 1004.01 - 1004.02
(e)	Admixtures	1021
(f)	Fly Ash	1010.03
(g)	Membrane Curing Compound	1022.01
(h)	Burlap Curing Blankets	1022.02
(i)	Waterproof Paper Blankets	1022.03
(j)	White Polyethylene Sheeting	1022.04
(k)	Burlap-Polyethylene Blanket	1022.05
(l)	Straw	1081.06(a)(1)

**1020.03** Equipment. Equipment shall meet the requirements of the following Articles of Section 1100 - Equipment:

Item	Article/Section
(a) Concrete Mixers	1103.01
(b) Batching and Weighing Equipment	1103.02
(c) Automatic and Semi-Automatic Batching Equipment	
for Portland Cement Concrete	1103.03
(d) Water Supply Equipment	1103.11
(e) Membrane Curing Equipment	1101.09
(f) Mobile Portland Cement Concrete Plants	1103.04

**1020.04** Concrete Classes and General Mix Design Criteria. The classes of concrete shown in the following Table 1 identify the various mixtures by the general uses and mix design criteria. If the class of concrete for a specific item of construction is not specified, Class SI Concrete shall be used.

Special classifications may be made for the purpose of including the concrete for a particular use or location as a separate pay item in the contract. The concrete used in such cases shall conform to this section.

Class of Concrete	Use	Specification Section Reference	Cen Fac	nent ctor m3	Max. Water/Cement Ratio kg/kg
			Min	Max	
BD	Bridge Deck	503	360		0.44
PC	Precast Concrete Structures	504	335	418	0.44
	Precast Concrete Piles	512			
	Precast Concrete Barrier Temporary Concrete Barrier	637 704	335	418	0.44
PS	Precast Prestressed Members	504	335	418	0.44
	Precast Prestressed Piles	512			
PV	PCC Pavement Base Course Base Course Widen. Driveway Pav't	420, 421 353 354 423	335 (1) 360 (2)		
PP	PCC Pavement Patching	442	Ty I Cem 385 Ty III Cem 365	Ty I Cem 445 Ty III Cem 425	
MS	Massive Structures (except Superstructures)	503	335 (1) 360 (2)		
SI	Structures (except Br. Deck) Gutter Curb & Gutter Median Light Tower Foundations Light Pole Foundations Culverts Handrails Headwalls Paved Ditch Slope Wall Sidewalk Cast-In-Place Concrete Barrier Miscellaneous PCC Railroad Crossing	503 606 606 606 836 837 540 503 542 606 511 424	335 (1) 360 (2)		
sc	Seal Coat Concrete	503	335 (1) 360 (2)		
SH	PCC Shoulders Shoulder Curb	483 662	280		0.50

<sup>(1)</sup> Stationary mixed.(2) Truck mixed or shrink mixed.



TABLE	1. (CONT'D	) CLASS	ES OF P	ORTLAN	D CEMEN	IT CONCRETE	AND MIX	DESIGN CRITERIA
Class of Concrete	Slump, mm		Mix Design Compressive Strength, kPa		Flexu	Mix Design Flexural Strength, kPa		Coarse Aggregate Gradations Permitted
		3	Days 14	28	Days 3 14		_	
BD	50-100	3	Mean 27,500	20	ა	Mean 4650	5-8	CA-7, CA-11 or CA-14
PC	25-75			Min. 31,000			5-8	CA-7, CA-11,
	25-75			Min. 27,500			5-8	CA-14 or CA-7 & CA-16
PS	25-75			Min 34,500			5-8	CA-7, CA-11, CA-14 or CA-7 & CA-16
PV	20-40	Ty III Cem Min 24,000	Min 24,000		Ty III Cem Min 4500	Min 4500	5-8	CA-5 & CA-7 CA-5 & CA-11, CA-7, CA-11 or CA-14
PP	100 Max						4-7	CA-7, CA-11, CA-13, CA-14, or CA-16
MS	50-100		Min 24,000			Min 4500	5-8	CA-3 & CA-7, CA-3 & CA-11, CA-5 & CA-7, CA-5 & CA-11, CA-7 or CA-11
SI	50-100		Min 24,000			Min 4500	5-8	CA-7, CA-11 or CA-14
RR	50-100						4-7	CA-7, CA-11 or CA-14
sc	75-125		Min 24,000			Min 4500	N/A	CA-3 & CA-7, CA-3 & CA-11, CA-5 & CA-7, CA-7 & CA-11, CA-7 or CA-11
SH	20-40		Min. 18,500			Min. 3500	5-8	CA-5 & CA-7, CA-5 & CA-11, CA-7, CA-11, or CA-14

Class of Concrete	Use	Specification Section Reference	Fac	nent ctor /c.y.	Max. Water/Cement Ratio Ibs/lbs	
			Min	Max		
BD	Bridge Deck	503	6.05		0.44	
PC	Precast Concrete Structures	504	5.65	7.05	0.44	
	Precast Concrete Piles	512				
	Precast Concrete Barrier Temporary Concrete Barrier	637 704	5.65	7.05	0.44	
PS	Precast Prestressed Members	504	5.65	7.05	0.44	
	Precast Prestressed Piles	512				
PV	PCC Pavement Base Course Base Course Widen. Driveway Pav't	420, 421 353 354 423	5.65 (1) 6.05 (2)			
PP	PCC Pavement Patching	442	Ty I Cem 6.50 Ty III Cem 6.20	Ty I Cem 7.50 Ty III Cem 7.20		
MS	Massive Structures (except Superstructures)	503	5.65 (1) 6.05 (2)			
SI	Structures (except Br. Deck) Gutter Curb & Gutter Median Light Tower Foundations Light Pole Foundations Culverts Handrails Headwalls Paved Ditch Slope Wall Sidewalk Cast-In-Place Concrete Barrier Miscellaneous PCC Railroad Crossing	503 606 606 606 836 837 540 503 542 606 511 424 637 611	5.65 (1) 6.05 (2)			
sc	Seal Coat Concrete	503	5.65 (1) 6.05 (2)			
			6.05 (2)			
SH	PCC Shoulders Shoulder Curb	483 662	4.75		0.50	

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<sup>(1)</sup> Stationary mixed.(2) Truck mixed or shrink mixed.



TABLE	1. (CONT'D	) CLASS	ES OF P	ORTLAN	D CEMEN	T CONCRETE	AND MIX	DESIGN CRITERIA
Class of Concrete	Slump, inches	Mix Design Compressive Strength, psi		Mix Design Flexural Strenth, psi		Air Content, %	Coarse Aggregate Gradations Permitted	
			Days			Days	_	
		3	14	28	3	14		
BD	2-4		Mean 4000			Mean 675	5-8	CA-7, CA-11 or CA-14
PC	1-3			Min. 4500			5-8	CA-7, CA-11, CA-14 or
	1-3			Min. 4000			5-8	CA-7 & CA-16
PS	1-3			Min 5000			5-8	CA-7, CA-11 CA-14 or CA-7 & CA-16
PV	3/4 - 1 1/2	Ty III Cem Min 3500	Min 3500		Ty III Cem Min 650	Min 650	5-8	CA-5 & CA-7, CA-5 & CA-11, CA-7, CA-11 or CA-14
PP	4 Max						4-7	CA-7, CA-11, CA-13, CA-14, or CA-16
MS	2-4		Min 3500			Min 650	5-8	CA-3 & CA-7, CA-3 & CA-11, CA-5 & CA-7, CA-5 & CA-11, CA-7 or CA-11
SI	2-4		Min 3500			Min 650	5-8	CA-7, CA-11 or CA-14
RR	2-4						4-7	CA-7, CA-11 or CA-14
SC	3-5		Min 3500			Min 650	N/A	CA-3 & CA-7, CA-3 & CA-11, CA-5 & CA-7, CA-7 & CA-11, CA-7 or CA-11
SH	3/4 - 1 1/2		Min. 2700			Min. 500	5-8	CA-5 & CA-7, CA-5 & CA-11, CA-7, CA-11, or CA-14

### 1020.05 Other Concrete Criteria.

(a) Proportioning. For Class PC and Class PS Concrete, it shall be the Contractor's responsibility to determine the proportions of the materials for the concrete and to exercise quality control with respect to the mixture so that each batch of concrete entering into the members will meet the criteria specified herein. Before the work begins, the Contractor shall secure the Engineer's approval of the proportions of materials he/she proposes to use in the concrete and shall identify each of the materials as to name, source, brand, type, etc.

For all other classes of concrete, the Engineer will determine the proportions of materials for the concrete. The Engineer will furnish to prospective bidders, upon request, the approximate proportions by mass (weight) necessary to produce concrete having the required workability and strength, using aggregates from any approved commercial source. This information is only for the convenience of the bidder.

The Engineer reserves the right to determine, as the work progresses and as aggregates are delivered to the site of the work, the proportions of cement, water and aggregates actually furnished which will produce workable plastic concrete meeting the criteria specified herein. The proportions will be determined according to the procedure established in the latest "Manual of Instructions for Design of Concrete Mixtures". In case the proportions determined by the Engineer and used on the work vary from the approximate proportions previously furnished, because of changes in sources or variations in materials or for any other reason considered sufficient by the Engineer, no additional compensation will be paid to the Contractor.

For Class SC Concrete and for any other class of concrete that is to be deposited under water, the cement factor of the concrete mix shall be increased over the cement factor of the mix design by 10 percent and a high range water reducing admixture shall be added to increase the slump to 150 to 200 mm (6 to 8 inches).

(b) Admixtures. Except as specified, the use of admixtures to increase the workability or to accelerate the hardening of the concrete will be permitted only when approved in writing by the Engineer.

When the atmosphere or concrete temperature is 18 °C (65 °F.) or higher, a retarding admixture meeting the requirements of Article 1021.03 shall be used in the Class BD Concrete and pcc bridge deck overlays. The amount of retarding admixture to be used will be determined by the Engineer. The proportions of the ingredients of the concrete shall be the same as without the retarding admixture except that the amount of mixing water shall be reduced, as may be necessary, in order to maintain the consistency of the concrete as required. In addition, a high range water reducer meeting the requirements of Article 1021.03 shall be used in the Class BD Concrete. The amount of high range water reducer will be determined by the Engineer. Type 1 cement shall be used.

For Class PC and PS Concrete, a retarding admixture may be added to the concrete mixture when the concrete temperature is 18 °C (65 °F.) or higher. The Engineer may order or permit the use of a retarding or water-reducing admixture whenever the Engineer considers it appropriate.

At the Contractor's option, admixtures other than air entraining agents may be used for Class PP Concrete. Admixtures shall be those from the Department's Approved Admixtures List. When calcium chloride is used, it shall be in a solution conforming to that described in the "Manual of Instructions for Concrete Proportioning and Testing". When a water-reducing or retarding admixture is used, the cement content may be reduced by up to 18 kg/m<sup>3</sup> (0.30 hundredweight per cu. yd.).



For all other classes of concrete, at the option of the Contractor, or when specified by the Engineer, a water reducing admixture or a retarding admixture may be used. The amount of water reducing admixture or retarding admixture permitted will be determined by the Engineer. The air-entraining admixture and other admixtures shall be added to the concrete separately, and shall be permitted to intermingle only after they have separately entered the concrete batch. The sequence, method, and equipment for adding the admixtures shall be approved by the Engineer. The water reducing admixture shall not delay the initial set of the concrete by more than one hour. Type 1 cement shall be used. water-reducing admixture is added, a reduction in cement content of up to 18 kg/m<sup>3</sup> (0.30 hundredweight per cu. yd.), from the concrete designed for a specific slump without the admixture, will be permitted. approved high range water-reducer is used, a cement reduction of up to 36 kg/m<sup>3</sup> (0.60 hundredweight per cu. yd.), from a specific water cement ratio without the admixture, will be permitted based on a 14 percent minimum water reduction. Cement factor below 280 kg/m<sup>3</sup> (4.75 hundredweight per cu. yd.) for Class SH Concrete and below 320 kg/m<sup>3</sup> (5.35 hundredweight per cu. yd.) for the remaining classes will not be permitted.

The maximum slumps given in Table 1 may be increased to 175 mm (7 inches) when a high range water-reducing admixture is used for all classes of concrete except Class PV.



Fly Ash. At the Contractor's option, fly ash from approved sources may partially replace portland cement in concrete mixtures, for Class BD, PV, MS, SI, SC, and SH, except when blended cements are utilized or when high-early-strength is required.

Fly ash and all other materials proposed for portland cement concrete mix designs shall be furnished to the Engineer at least 60 days prior to the initiation of work. The Engineer may elect to waive the required mix designs if the proposed materials combination has been previously approved and has demonstrated satisfactory field performance.

If Class F fly ash is used, the amount of cement replaced shall not exceed 15 percent by mass (weight) and the replacement ratio (fly ash:cement replaced) shall be a minimum of 1.5:1. If Class C fly ash is used, the amount of cement replaced shall not exceed 20 percent by mass (weight), at a minimum replacement ratio of 1.25:1.



For bridge decks, parapets, pier and abutment caps, backwalls, wingwalls and the upper 750 mm (2.5 ft.) of solid piers, the amount of cement replaced shall not exceed 15 percent by mass (weight) at a minimum replacement ratio of 1.5:1, regardless of the type of fly ash used.

Measurements of fly ash and cement will be rounded up to the nearest 2.5 kg (5 lbs.).

Strength requirements for fly ash compensated mixes shall be a minimum of 95% of the requirements shown in Table 1 of Article 1020.04.

Requirements for opening the pavement and/or structures to traffic and removal of falsework shall be as stated in Article 701.05 and 503.05. For fly ash compensated mixtures, at least 28 days shall elapse in the absence of strength tests.

Fly ash shall not be used in concrete mixtures after October 15 nor before April 1 unless the Contractor provides lab test data demonstrating 14-day strength no less than that obtained from the equivalent cement-only mix.

Fly ash with an R factor greater than 3.0 shall not be used in concrete which will be subjected to high sulfate concentrations in soil or water. High sulfate soils shall be those with concentrations of water soluble sulfate (as SO<sub>4</sub>) greater than 0.10 percent, and high sulfate waters shall be those with sulfate concentrations (as SO<sub>4</sub>) greater than 150 mg/L.

- (d) Class BD Concrete. The maximum mortar factor will be 0.83.
- (e) Class PS Concrete. The cement used in the mix shall be Type I or Type III portland cement.
- (f) Class PV Concrete. The following special criteria shall apply to Class PV:
  - (1) A slump above the maximum specified in Table 1 of Article 1020.04 may be used with the Engineer's approval, up to a maximum of 75 mm (3 inches), provided the mixture's water/cement ratio does not exceed 0.42.
  - (2) Small quantities of Class SI may be used with the Engineer's approval. A unit coarse aggregate according to Article 1004.02(d) and (f) and Table 1 of Article 1020.04 will be required.
  - (3) The mortar content of the first 8 m³ (10 cu. yds.) or 2 batches, whichever is the greater, that is to be placed adjacent to a previously constructed transverse construction joint, shall be increased by the addition of cement and fine aggregate at the rates of 30 and 70 kg/m³ (50 and 120 lbs. per cu. yd.), respectively.
  - (4) Class SI Concrete may be used for the construction of driveway pavement provided the coarse aggregate contained in the mixture complies with the Department's freeze-thaw requirements for pavement.
- (g) Class PP Concrete. The following special criteria shall apply:
  - (1) Early Strength Patching Mixture. Either Type III high-early-strength portland cement, a rich mix of Type I portland cement, or a concrete mixture containing an approved accelerator shall be used. The concrete mix design will be based on obtaining a compressive strength of not less than 22000 kPa (3200 psi) or a modulus of rupture of not less than 4150 kPa (600 psi) at the age of 2 days.
  - (2) Special Patching Mixture. Special patching mixture shall consist of the

approximate proportions of materials per cubic meter (cubic yard):

Coarse Aggregate	1020 kg (1720 lbs.)
Fine Aggregate	665 kg (1120 lbs.)
Cement	440 kg (735 lbs.)
Water	145 kg (242 lbs.)
	[145 L (29 gals.)]
Accelerator	10 L (2 gals.)
High Range Water Reducer	5-10 L (1-2 gals.)
Air Content	4-6%

The coarse aggregate shall be CA 7, CA 11, CA 14, or CA 16. Type I portland cement shall be used. The accelerator may be an approved admixture or it may be a calcium chloride solution conforming to that described in the Department's "Manual of Instructions for Concrete Proportioning and Testing". The water/cement ratio shall be no greater than 0.38 after the admixtures are added. The dosage of high range water reducer will be adjusted dependent upon brand and upon whether Type E (water reducing) accelerator or Type C (nonwater reducing - this includes calcium chloride solution) accelerator is used. The final slump shall be not more than 150 mm (6 inches).

The accelerator and high range water reducer shall be added to the truck mixer at the job site. The accelerator shall be added to the mixture before the high range water reducer. The truck mixer shall be reversed to discharge position so that the concrete is moved to the rear of the drum with discharge imminent. The accelerator shall then be added by dispensing directly onto the concrete and mixed 40 revolutions. After the accelerator has been mixed, the truck mixer shall again be reversed and the high range water reducer added and mixed in the same manner as the accelerator.

The air content will be verified after the admixtures have been mixed into the concrete.

Since this mixture stiffens rapidly under high ambient temperature conditions, no more than  $2.5~\text{m}^3$  (3 cu. yds.) should be batched per truck unless the truck can be discharged. Retempering with water will not be permitted.

This special patching mixture is intended to permit patches to be constructed and opened the same day and as soon as the flexural strength reaches the requirements of Article 701.05(e)(2)c. It is intended for use under hot ambient conditions [greater than 27 °C (80 °F.)] and will not perform as satisfactorily under cooler conditions. When the air temperature in the shade is between 13 °C and 27 °C (55 °F. and 80 °F.) the mixture may be modified to offset the effects of the cooler conditions by using CA 7 or CA 11 coarse aggregate to reduce water demand, by increasing the dosage rate of calcium chloride solution up to 23.8 L/m³ (4.8 gals. per cu. yd.), and by heating the mixing water to bring the plastic concrete to 29 °C (85 °F.) minimum temperature.

(h) Class SI Concrete. When used as slipformed concrete, the slump shall be not less than 13 mm (1/2 inch) nor more than 30 mm (1 1/4 inches)

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- (i) Class RR Concrete. The following special criteria shall apply:
  - (1) The concrete mix design will be based on obtaining a compressive strength of not less than 24 MPa (3500 psi) or a modulus of rupture of not less than 4.5 MPa (650 psi) before the concrete crossing is opened to railroad traffic.
  - (2) Early strength concrete, either Type III portland cement or a rich mix of Type I portland cement, shall be used.
  - (3) It may be necessary to increase the mixing time to 2 minutes for the rich mix.
  - (4) Calcium chloride not to exceed 1 percent of the mass (weight) of cement in the mix may be added.
  - (5) The Department reserves the right to select the method to be used in obtaining high early strength, and to make such specimens and tests of the concrete as may be deemed necessary.
- (j) Class SH Concrete. The following special criteria shall apply:
  - The fine aggregate volume shall not exceed the coarse aggregate volume.
  - (2) The special criteria (1), (2), and (3) for Class PV shall also apply.

**1020.06 Water/Cement Ratio.** The water/cement ratio is determined on a mass (weight) basis. When a maximum water/cement ratio is specified, the water shall include wash water, mixing water, water in admixtures, free moisture in the aggregates, and water added at the jobsite. The quantity of water may be adjusted by the Engineer, within the limit specified, to meet slump requirements.

When fly ash, ground granulated blast furnace slag, or microsilica are used as part of the cement in a concrete mix, the water/cement ratio will be based on the total cementitious material contained in the mixture.

**1020.07** Slump. The slump will be determined according to AASHTO T 119.

Slump tests will be made as required by the "Manual for Inspectors of Precast Prestressed Concrete Products" for Class PC and PS, and as required by the "Project Procedures Guide" for all other classes. If the measured slump falls outside the limits specified, a check test will be made. In the event of a second failure, the Engineer may refuse to permit the use of the batch of concrete represented. At the time of placement, the slump of the concrete discharged from the container shall conform to Article 1020.04 and 1020.05.

The mixture shall contain no more water than is necessary to produce concrete which is workable and plastic. The amount of water used will be determined by the Engineer. Corrections shall be made for the amount of moisture contained in the aggregates and allowance shall be made for absorption of moisture by the aggregates during the period of mixing and handling. A uniform consistency shall be maintained continuously.

If it is found impossible to prepare concrete of the specified consistency without exceeding the maximum design water content, additional cement or a water reducing admixture shall be added at no additional cost to the Department.

Equipment for conducting slump tests shall be furnished by the Contractor for

Class PC or PS and by the Engineer for all other classes.

**1020.08 Air Content.** The air content shall be according to Articles 1020.04 and 1020.05 and shall be determined according to the Illinois Modified AASHTO T 152 or AASHTO T 196. The air-entrainment shall be obtained either by the use of air-entraining portland cement or by the use of nonair-entraining portland cement with an approved air-entraining admixture added during the process of mixing the concrete.

If the air-entraining portland cement furnished should be found to produce concrete having an air content outside the limits specified, its use shall be discontinued immediately and the Contractor shall provide other air-entraining portland cement which will produce air contents within the specified limits, or the Contractor may blend nonair-entraining portland cement at the batch plant with the Engineer's approval.

If the air content obtained is above the specified maximum limit at the jobsite, the Contractor, with the Engineer's approval, may add to the truck mixer nonair-entraining portland cement in the proportion necessary to bring the air content within the specified limits, or the concrete may be further mixed, within the limits of time and revolutions specified, to reduce the air content. If the air content obtained is below the specified minimum limit, the Contractor may add to the concrete during the process of mixing, a sufficient quantity of an approved air-entraining admixture at the job site to bring the air content within the specified limits.

Air-entraining admixture shall be added to the concrete by means of a mechanically activated dispenser meeting the requirements of Article 1103.03(a)(4), and permitting visual determination of the quantity dispensed. The air-entraining admixture shall be introduced into the stream of mixing water, and the required amount shall be fully discharged before all the mixing water has entered the drum. The tank feeding the dispenser shall at all times contain an amount of air-entraining admixture sufficient for the next batch, and shall be provided with a device, approved by the Engineer, for indicating visually when the supply runs low. The amount to be used shall be determined and shall be varied during the progress of the work, on the basis of air content determinations made by the Engineer to obtain air contents of the concrete within the specified limits.

Air tests will be as required by the "Manual for Inspectors of Precast Prestressed Concrete Products" for Class PC and PS Concrete, and as required by the "Project Procedures Guide" for all other classes of concrete. Equipment for conducting air tests shall be furnished by the Contractor for Class PC and PS, and by the Engineer for all other classes.

**1020.09 Strength Tests.** The compressive strength shall be determined according to AASHTO T 22. The flexural strength shall be determined according to the Illinois Modified AASHTO T 177. Details for fabricating, handling, curing, and testing the specimens for the various classes shall be according to the following. All costs to the Contractor for materials, labor, and equipment furnished in connection with fabricating, handling, transporting, storing, curing, and testing concrete specimens as hereinafter specified shall be included in the unit prices bid for the respective portland cement concrete items, and no additional compensation will be allowed.

(a) Class PC Concrete. The Contractor shall make, cure and test the concrete test specimens as directed by the Engineer. A minimum of 4 test cylinders shall be made for each 7 units constructed in a day or a minimum of 4 specimens per day if less than 7 units are constructed. The test specimens shall remain with the units they represent and shall be subject to the same curing as the units until the time of testing.

The number of test specimens should be sufficient for determining the specified concrete strengths accurately. If the supply of test cylinders becomes exhausted, cores for additional tests shall be taken from the units as directed by the Engineer.

- (b) Class PS Concrete. A minimum of 6 concrete test cylinders shall be made in approved molds furnished by the Contractor from the concrete used in each casting bed. The procedures for making, handling, curing and testing the test specimens shall be as outlined in the "Manual for Inspectors of Precast Prestressed Concrete Products".
- (c) All Other Classes of Concrete. The Engineer reserves the right to make compression and flexural strength tests of the concrete or to waive such tests when it is impractical to make them. The specimens shall be molded and cured according to AASHTO T 23. The number of test specimens made and tested for the various portland cement concrete items shall be as outlined in the Department's "Project Procedures Guide".

The test specimens shall be made from concrete taken from the mixtures in actual use. The Contractor shall transport the specimens from the site of the work to the field laboratory or other location on the work designated by the Engineer. During transportation, the specimens shall be embedded in straw, burlap, or other acceptable material in a manner meeting with the approval of the Engineer to protect them from damage; care shall be taken to avoid impacts during hauling and handling. Testing equipment and forms for the specimens will be furnished by the Department. The Contractor shall furnish the concrete used in making test specimens; a suitable light truck for use in transporting specimens; materials necessary for proper transportation and curing; and labor incidental to the preparation, transportation, storage, curing and testing.



**1020.10 Handling, Measuring, and Batching Materials.** Aggregates shall be handled from stockpiles or other sources to the plant in a manner to secure a uniform grading of the material. Aggregates that have become segregated, or mixed with earth or foreign material, shall not be used. All aggregates produced or handled by hydraulic methods, and washed aggregates, shall be stockpiled or binned for draining at least 12 hours before being batched. Rail shipment requiring more than 12 hours will be accepted as adequate binning only if the car bodies permit free drainage. In case the aggregates contain high or nonuniform moisture content, storage or stockpile periods in excess of 12 hours may be required by the Engineer.

Each separated size of coarse aggregate shall not be moved directly from the cars to the proportioning bins unless the aggregate particles have been mixed uniformly before or during loading of the cars. Coarse aggregate not so loaded shall be placed in a stockpile and mixed uniformly before being placed in the proportioning bins. The fine aggregate and coarse aggregate shall be separately weighed into hoppers in the respective amounts set by the Engineer in the job mix.

Cement shall be measured by mass (weight). Separate scales and hoppers shall be used for measuring the cement, with a device to indicate positively the complete discharge of the batch of cement. When fly ash is being used to replace a portion of the cement, the fly ash shall be measured in a separate weigh hopper when a manual operation is utilized. When an automatic batching plant is utilized, the fly ash may be measured into the cement hopper. Cement and fly ash hoppers shall be

separated to the satisfaction of the Engineer.

Water may be measured either by volume or by mass (weight). The accuracy of measuring the water shall be within a range of error of not over 1 percent, and the water measuring equipment shall include an auxiliary tank from which the measuring tank shall be filled. The measuring tank shall be equipped with an outside tap and valve to provide for checking the setting, unless other means are provided for readily and accurately determining the amount of water in the tank. The volume of the auxiliary tank shall be at least equal to that of the measuring tank.

Batching plants shall be equipped to proportion aggregates and cement by mass (weight) manually or by means of automatic and interlocked proportioning devices of approved type. Only automatic batching plants shall be used to produce Class PV concrete.

The Engineer may permit the Contractor to proportion the aggregates and cement by volume for the concrete in small isolated structures and for miscellaneous and incidental concrete items. Aggregates and cement shall be measured separately by volume using measuring devices approved by the Engineer. The volume of fine or coarse aggregate and cement shall be based upon dry, loose materials.

**1020.11 Mixing Portland Cement Concrete.** The mixing requirements vary somewhat, depending on the class of concrete and its specific use. Two types of concrete are used - jobsite mixed or ready-mixed. Jobsite-mixed concrete is mixed in a stationary mixer and transported to the place of deposit in an agitating or nonagitating truck. Ready-mixed concrete may be mixed in a stationary mixer at the ready-mix plant and transported to the jobsite in agitating or nonagitating trucks or it may be batched at the ready-mix plant and mixed and hauled to the jobsite in truck mixers.

The specific mixing requirements for the various classes of concrete are as follows:

(a) Class PC Concrete. Class PC Concrete shall be mixed in a jobsite mix plant or may be obtained from a ready-mix plant.

If a jobsite mix plant is used, the mixer and batching equipment shall conform to Article 1103.01(a) and 1103.02, shall be an integral part of the plant equipment, and shall be approved by the Engineer. Mixing in the stationary mixer shall conform to the requirements in Article 1020.11(c), except that the mixing time, after all materials except water are in the drum, shall be not less than 1 minute for mixers having a capacity of 1.5 m³ (2 cu. yds.) or less. A truck mixer may be used provided it meets the requirements specified for Class PS Concrete in (b) below.

If ready-mixed concrete is used, the ready-mix plant furnishing the concrete shall be certified under the latest NRMCA certification of Ready-Mix Concrete Production Facilities and shall produce the specified concrete mixture. Each ready-mix plant shall furnish the Engineer a copy of the certification which shall be good for 2 years after certification.

(b) Class PS Concrete. Class PS Concrete shall be mixed in a jobsite mix plant that is an integral part of the prestressing plant as specified above in Article 1020.11(a).

If approved in writing by the Engineer, a truck mixer and batching plant that are an integral part of the prestressing plant equipment may be used

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provided the mixing conforms to the requirements of Article 1020.11(d) and to the following:

- (1) Measurements and addition of mixing water shall comply with the requirements of Article 1020.11(d), except all wash water shall be completely discharged from the drum or container before the succeeding batch is placed.
- (2) The truck mixer shall be capable of discharging concrete with a slump of 50 mm (2 inches).
- (3) Truck mixers which do not obtain complete and uniform mixing of the batch materials and which have variations in slump greater than 20 mm (3/4 inch) within or between batches will be rejected until such time as they have been repaired and approved for mechanical condition.
- (4) Batching facilities and procedures that do not provide satisfactorily mixed concrete will not be permitted.

Concrete from a ready-mix plant will not be permitted for use in Class PS Concrete construction except to complete the casting of a beam in the case of a breakdown in concrete-supplying equipment. The ready-mix plant furnishing the concrete shall be certified under the latest NRMCA certification of Ready-Mix Concrete Production Facilities and the mixture furnished shall be that specified for the beam. Each ready-mix plant shall furnish the Engineer a copy of the certification which shall be good for 2 years after certification.

(c) Class PV and SH Concrete. Except as hereinafter permitted for truck-mixed concrete, Class PV and SH Concrete shall be mixed in a stationary mixer conforming to Article 1103.01(a). The stationary mixer shall be at an approved location and used exclusively for work subject to inspection by the Engineer. The plastic concrete shall be hauled to the construction site in agitator or nonagitator trucks conforming to Article 1103.01(c) and (d).

The stationary mixer shall operate at the drum speed for which it was designed. The batch shall be charged into the drum so that some of the water shall enter in advance of the cement and aggregates. The flow of the water shall be uniform and all water shall be in the drum by the end of the first 15 seconds of the mixing period. As an objective, water should begin to enter the drum from 0 to 2 seconds in advance of solid material and should stop flowing within 2 seconds of the beginning of mixing time.

Some coarse aggregate shall enter in advance of other solid materials. For the balance of the charging time for solid materials, the aggregates and cement (to assure thorough blending) shall each flow at acceptably uniform rates, as determined by visual observation. Coarse aggregate should enter 2 seconds in advance of other solid materials and a uniform rate of flow should continue to within 2 seconds of the completion of charging time.

The entire contents of the drum, or of each single compartment of a multiple-drum mixer, shall be discharged before the succeeding batch is introduced.

The volume of concrete mixed per batch shall not exceed by more than 10 percent the mixer's rated capacity as shown on the standard rating plate

on the mixer.

The minimum mixing time shall be 75 seconds for a stationary mixer. Transfer time in multiple drum mixers is included in the mixing time. Mixing time shall begin when all solid materials are in the mixing compartment and shall end when the discharge of any part of the batch is started. The required mixing times will be established by the Engineer for all types of stationary mixers.

The required mixing time for stationary mixers may be less than 75 seconds upon satisfactory completion of a mixer performance test. Mixer performance tests may be requested by the Contractor when the quantity of concrete to be placed exceeds 42000 m² (50,000 sq. yds.). The tests will be conducted according to the standard methods adopted by the Department.

The Contractor will be allowed to test 2 mixing times within a range of 50 to 75 seconds. If satisfactory results are not obtained from the required tests, the mixing time shall continue to be 75 seconds for the remainder of the contract. If satisfactory results are obtained, the acceptable mixing time may be reduced for those particular circumstances to the mixing time which test results indicate to provide satisfactory mixing. In no event will mixing time be less than 50 seconds.

No additional compensation will be allowed the Contractor for any delays or inconveniences if the Contractor elects to change the mixing time. The Contractor shall furnish the labor, equipment, and material required by the Engineer to make the tests listed above with the cost being included in the unit bid prices for the various items of portland cement concrete involved.

When mixer performance tests have been successfully completed and a reduced mixing time has been established, the Contractor may request, in writing, permission to operate this same plant and mixer setup on other pavement or base course contracts at the reduced established mixing time. Approval by the Engineer will depend upon past performance. If, in the Engineer's opinion, conditions have changed so as to affect the quality of concrete, the Engineer may require additional tests.



Truck-mixed concrete will be permitted on mainline pavement or base course less than 0.8 km (1/2 mile) in length and areas outlined in Article 420.11(a)(3). The concrete shall be produced as specified in Article 1020.11(d). Truck-mixed concrete may be permitted on contracts exceeding 0.8 km (1/2 mile) in length of portland cement concrete pavement or base course providing the ready-mix plant is certified under the latest NRMCA certification of Ready-Mix Concrete Production Facilities and produces concrete meeting the restrictions listed below.

Each ready-mix plant shall furnish the Engineer a copy of the certification which shall be good for 2 years after certification. Subject to the approval of the Engineer and the restrictions listed below, a batch plant may be used to batch the materials directly to truck mixers.

In addition to the requirements listed in Article 1020.11(d) for ready-mixed concrete, the following restrictions shall apply:

(1) The plant operations shall be able to consistently maintain a minimum

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delivery of 38 m<sup>2</sup> (50 cu. yds.) of concrete per hour.

- (2) All mixing water shall be added at the batch plant and no water may be added at the jobsite to exceed the design slump. All wash water shall be discharged prior to batching the concrete materials in the mixer.
- (3) The truck mixers shall be capable of discharging a concrete with slump not exceeding 50 mm (2 inches) at a rate of not more than 65 sec./m<sup>3</sup> (50 sec. per cu. yd.).
- (4) Truck mixers which do not obtain complete and uniform mixing of the batch materials and which have variations in slump greater than 20 mm (3/4 inch) within or between batches shall be rejected until such time as they have been repaired and approved by the Engineer.
- (5) Batching facilities and procedures that do not provide satisfactorily mixed concrete will not be permitted.
- (d) All Other Classes of Concrete. The concrete shall be mixed at the site of work only in the quantities required for immediate use or ready-mixed concrete shall be used.

When the concrete is mixed at the site of the work, a stationary mixer conforming to Article 1103.01(a) shall be used and the mixing shall be performed according to Article 1020.11(c) except that the minimum mixing time shall be 1 minute for mixers having a capacity of 1.5 m<sup>3</sup> (2 cu. yds.) or less.

When ready-mixed concrete is used, it shall be transported to the work in truck mixers, truck agitators or nonagitating trucks having special bodies. Ready-mixed concrete is a stationary-mixed, truck-mixed, or shrink mixed concrete meeting the following requirements:

(1) Stationary-Mixed Concrete. Stationary-mixed concrete is concrete which has been completely mixed in a stationary mixing plant approved by the Engineer.

The mixer shall be rotated at the rate recommended by its manufacturer. The mixing time shall be measured from the time that all cement and aggregates are in the mixer. The batch shall be charged into the drum so that some water shall enter in advance of the aggregates. The flow of the water shall be uniform and all water shall be in the drum by the end of the first 15 seconds of the mixing period. When the stationary mixing plant is used for the complete mixing of the concrete to be transported as wet batches, the mixing time for mixers having a capacity of 1.5 m<sup>3</sup> (2 cu. yds.) or less shall be not less than one minute; for mixers of larger capacity, this minimum mixing time shall be 75 seconds.

The vehicles used for transporting the mixed concrete shall be of such capacity, or the batches shall be so proportioned, that the entire contents of the mixer drum can be discharged into each vehicle load.

(2) Truck-Mixed Concrete. Truck-mixed concrete is completely mixed in a truck mixer. When the mixer is charged with fine and coarse aggregates simultaneously, not less than 60 nor more than 100 revolutions of the drum or blades at mixing speed shall be required, after all of the ingredients including water are in the drum. When fine and coarse aggregates are charged separately, not less than 70 revolutions will be required. Additional mixing beyond 100 revolutions shall be at agitating speed unless additions of water and/or admixtures are made at the direction of the Engineer. The mixing operation shall begin immediately after the cement and water, or the cement and wet aggregates, come in contact. The ingredients of the batch shall be completely discharged from the drum before the succeeding batch is introduced. Drums and auxiliary parts of the equipment shall be kept free from accumulations of materials. If additional water or an admixture is added at the jobsite, the concrete batch shall be mixed a minimum of 40 additional revolutions after each addition.

- (3) Shrink-Mixed Concrete. Shrink-mixed concrete is mixed partially in a stationary mixer and completed in a truck mixer. The mixing time at the stationary mixing plant may be reduced to a minimum of 30 seconds to intermingle the ingredients, before transferring to the truck mixer. All ingredients for the batch shall be in the stationary mixer and partially mixed before any of the mixture is discharged into the truck mixer. The partially mixed batch shall be transferred to the truck mixer without delay and without loss of any portion of the batch, and mixing in the truck mixer shall start immediately. The mixing time in the truck mixer shall be not less than 50 nor more than 100 revolutions of the drum or blades at mixing speed. Units designed as agitators shall not be used for shrink mixing. Except for the preceding requirements, shrink mixing shall conform to the requirements in (2) for truck-mixed concrete.
- (4) Agitating. Agitating is the process of continuing the mixing of concrete in a truck mixer or agitator for the purpose of preventing segregation while in transit to the destination.

When stationary-mixed concrete is to be transported in a truck agitator or a truck mixer, the stationary-mixed batch shall be transferred to the agitating unit without delay and without loss of any portion of the batch. Agitating shall start immediately thereafter and shall continue without interruption until the batch is discharged from the agitator. The ingredients of the batch shall be completely discharged from the agitator before the succeeding batch is introduced. Drums and auxiliary parts of the equipment shall be kept free from accumulations of materials.

(5) Mixing Water. No additional water may be added at the jobsite to stationary mixed concrete if a reduction in the cement factor has been given for stationary mixed concrete. All mixing water shall be added at the batch plant and no water may be added at the jobsite to exceed the design slump.

Washing water, if used, shall be either completely discharged from the drum or container before the succeeding batch is introduced, or if permitted by the Engineer, remain as a portion of the mixing water for the succeeding batch, and shall be accurately measured and taken into account in determining the amount of additional mixing water required.

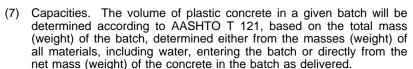
(6) Mixing and Agitating Speeds. The mixing speed for the revolving drum

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type of truck mixer shall be the manufacturer's recommended speed as displayed on the rating plate. If the concrete is inadequately mixed, the mixing speed shall be not less than 5 revolutions per minute of the drum, nor greater than a speed resulting in a peripheral velocity of the drum of 69 m (225 ft.) per minute. For the revolving blade type of mixer, the mixing speed shall be not less than 5 nor more than 16 revolutions per minute of the mixing blades.

Agitating speed, for both the revolving drum and revolving blade types, shall be not less than 2 nor more than 5 revolutions per minute of the drum or of the mixing blades.

Mixing blades in mixers and agitators which become worn down 20 mm (3/4 inch) or more in width shall be replaced with new blades.



The volume of batch in the truck mixer or the truck agitator shall in no case be greater than the rated capacity determined according to the Truck Mixer and Agitator Standards of the Truck Mixer Manufacturer's Bureau, as shown by the rating plate. If the truck mixer or truck agitator does not have a rating plate complying with these standards, the allowable capacity will be determined by the Engineer on the basis of the interior gross volume of the drum.

For the purpose of determining the gross volume of the container of the revolving blade type of truck mixer or agitator, the height of the container above the center shaft will be considered no greater than the radius of the circular section of the container below the center shaft, and the overall width will be considered no greater than the diameter of the circular section.

(8) Time of Haul. Haul time shall begin when the delivery ticket is stamped. The delivery ticket shall be stamped no later than 5 minutes after the addition of the mixing water to the cement and aggregates, or after the addition of the cement to the aggregate when the mixer drum contains residual water or the combined aggregates contain free moisture in excess of 2 percent by mass (weight). Haul time shall end when the truck is emptied for incorporation of the concrete into the work. For concrete mixed in jobsite stationary mixers, the stamped delivery ticket may be waived, but a method of verifying the haul time shall be established to the satisfaction of the Engineer.

The time elapsing from when water is added to the mix until it is deposited in place at the site of the work shall not exceed 30 minutes when the concrete is transported in nonagitating trucks.

Concrete transported in truck mixers or truck agitators shall be delivered to the site of the work in a plastic and workable condition, satisfactory for placement in the work without the addition of water or water and cement prior to discharging.



The maximum haul time for concrete transported in truck mixers or truck agitators shall be according to the following:

Concrete Ten at Point of Disch		Ha <u>Hours</u>	ul Time <u>Minutes</u>
10-17.5 18-32	(50-64) (65-90)	1 1	30 0 vithout retarder)
18-32	(65-90)	1 `	30 with retarder)

To encourage start-up testing for mix adjustments at the plant, the first 2 trucks will be allowed an additional 15 minutes haul time whenever such testing is performed.

The producer of ready-mixed concrete shall furnish proof of compliance with the above requirements with each delivery of concrete in the form of a ticket stamped by an approved time clock. Each ticket shall be delivered to the Engineer or his/her representative upon arrival on the job.

(9) Production and Delivery. The production of ready-mixed concrete shall be such that the operations of placing and finishing will be continuous insofar as the job operations require. The Contractor shall be responsible for producing concrete that will have the required consistency when delivered to the work. Concrete which is unsuitable for placement as delivered will be rejected.

The Engineer may require such modification of procedures as will produce satisfactory results. If it proves impracticable to complete the work before the concrete becomes too stiff to finish properly, the Engineer may order the discontinuance of the use of ready-mixed concrete.

**1020.12 Mobile Portland Cement Concrete Plants.** The use of a mobile portland cement concrete plant may be approved under the provisions of Article 1020.10 for volumetric proportioning in small isolated structures, thin overlays, and for miscellaneous and incidental concrete items.

The first 0.03 m<sup>3</sup> (cubic foot) of concrete produced may not contain sufficient mortar and shall not be incorporated in the work. The side plate on the cement feeder shall be removed periodically (normally the first time the mixer is used each day) to see if cement is building up on the feed drum.

Sufficient mixing capacity of mixers shall be provided to enable continuous placing and finishing insofar as the job operations and the Specifications require.

Slump and air tests made immediately after discharge of the mix may be misleading, since the aggregates may absorb a significant amount of water for 4 or 5 minutes after mixing.

**1020.13 Curing and Protection.** The methods of curing and protection and the length of the curing period vary somewhat, depending on the type of construction

involved. A ready reference for the method of curing, curing period, and method of protection for each of the various types of concrete construction is included in the following Index Table.

INDEX TABLE OF CURING AND PROTECTION OF CONCRETE CONSTRUCTION				
TYPE OF CONSTRUCTION	CURING METHODS	CURING PERIOD DAYS		
Pavement Base Course Base Course Widening Driveways Median Concrete Gutter, Curb	1020.13(a)(1)(2)(3)(4) <sup>3/6/</sup> 1020.13(a)(1)(2)(3)(4) <sup>1/2/</sup> 1020.13(a)(1)(2)(3)(4) <sup>1/2/</sup> 1020.13(a)(1)(2)(3)(4) <sup>4/6/</sup> 1020.13(a)(1)(2)(3)(4) <sup>4/6/</sup>	3 3 3 3	1020.13(c) 1020.13(c) 1020.13(c) 1020.13(c) 1020.13(c)	
Combination Curb and Gutter Sidewalk Slope Wall Paved Ditches Catch Basin, Manhole, Inlet	1020.13(a)(1)(2)(3)(4) <sup>4/6/</sup> 1020.13(a)(1)(2)(3)(4) <sup>4/6/</sup> 1020.13(a)(1)(2)(3)(4) <sup>4/6/</sup> 1020.13(a)(1)(2)(3)(4) <sup>4/</sup>	3 3 3 3	1020.13(c) 1020.13(c) 1020.13(c) 1020.13(c)	
and Valve Vault Pavement Patching Pavement Replacement Railroad Crossing Piling5/ Footings, Foundations	1020.13(a)(1)(2)(3)(4)4/ 1020.13(a)(1)(2)(3)(4)2/ 1020.13(a)(1)(2)(3)(4)1/2/ 1020.13(a)(3) 1020.13(a)(3) 1020.13(d), 1020.13(a)(1)	3 3/7 3 1 7	1020.13(c) 1020.13(c) 1020.13(c) 1020.13 1020.13(e)(1)(2)(3)	
Substructure Superstructure (except deck) Deck Retaining Walls Pump House Culverts and Headwalls Other Incidental Concrete Precast Concrete Members	(3)(4) <sup>4/</sup> 1020.13(d)(2) <sup>1/</sup> 1020.13(a)(1)(2)(3) 1020.13(a)(3) 1020.13(d)(2) <sup>1/</sup> 1020.13(d)(2) <sup>1/</sup> 1020.13(d)(2) <sup>4/</sup> 1020.13(a)(1)(2)(3)	7 7 7 7 7 7 7 7 7 3 e Section	1020.13(e)(1)(2)(3) 1020.13(e)(1)(2)(3) 1020.13(e)(1)(2) 1020.13(e)(1)(2) 1020.13(e)(1)(2) 1020.13(e)(1)(2) 1020.13(e)(1)(2) 1020.13(c)(1)(2)	

### Notes-General:

- 1/ Type I, membrane curing only
- 2/ Type II, membrane curing only
- 3/ Type III, membrane curing only
- 4/ Type I, II and III membrane curing
- 5/ See Section 512 for additional requirements
- 6/ Membrane Curing will not be permitted between November 1 and April 15.
- 7/ Curing maintained only until opening strength is attained, with a maximum curing period of 3 days.
- (a) Methods of Curing. Except as provided for in the above Table, curing shall

be accomplished by one of the following described methods. When water is required to wet the surface, it shall be applied as a fine spray so that it will not mar or pond on the surface. Except where otherwise specified, the curing period shall be at least 72 hours. If high-early-strength portland cement is permitted, the curing period may be reduced as directed by the Engineer.

(1) Waterproof Paper Method. The surface of the concrete shall be covered with waterproof paper as soon as the concrete has hardened sufficiently to prevent marring the surface. The surface of the concrete shall be wetted immediately before the paper is placed. The blankets shall be lapped at least 300 mm (12 inches) end to end, and these laps shall be securely weighted with a windrow of earth, or other approved method, to form a closed joint. The same requirements shall apply to the longitudinal laps where separate strips are used for curing edges, except the lap shall be at least 225 mm (9 inches). The edges of the blanket shall be weighted securely with a continuous windrow of earth or any other means satisfactory to the Engineer to provide an air-tight Any torn places or holes in the paper shall be repaired immediately by patches cemented over the openings, using a bituminous cement having a melting point of not less than 82 °C (180 °F.) The blankets may be reused, provided they are air-tight and kept serviceable by proper repairs.

A longitudinal pleat shall be provided in the blanket to permit shrinkage where the width of the blanket is sufficient to cover the entire surface. The pleat will not be required where separate strips are used for the edges. Joints in the blanket shall be sewed or cemented together in such a manner that they will not separate during use.

The Engineer may approve the use of other impermeable covering, in lieu of waterproof paper, provided it has been shown through laboratory and field investigation that the results obtained are at least as satisfactory as those obtained with waterproof paper.

Polyethylene Sheeting Method. The surface of the concrete shall be covered with white polyethylene sheeting as soon as the concrete has hardened sufficiently to prevent marring the surface. The surface of the concrete shall be wetted immediately before the sheeting is placed. The edges of the sheeting shall be weighted securely with a continuous windrow of earth or any other means satisfactory to the Engineer to provide an air-tight cover. Adjoining sheets shall overlap not less than 300 mm (12 inches) and the laps shall be securely weighted with earth, or any other means satisfactory to the Engineer, to provide an air-tight cover. For portland cement concrete surface and base course, the polyethylene sheets shall be not less than 30 m (100 ft.) in length nor longer than can be conveniently handled, and shall be of such width that, when in place, they will cover the full width of the surface, including the edges, except that separate strips may be used to cover the edges. Any torn places or holes in the sheeting shall be repaired by cemented patches. When sheets are no longer serviceable as a single unit, the Contractor may select from such sheets and reuse those which will serve for further applications, provided two sheets are used as a single unit; however, the double sheet units may be rejected when the Engineer deems that they no longer provide an air-tight cover.

(3) Wetted Burlap Method. The surface of the concrete shall be covered with wetted burlap blankets as soon as the concrete has hardened sufficiently to prevent marring the surface. The blankets shall overlap 150 mm (6 inches). At least 2 layers of wetted burlap shall be placed on the finished surface. The burlap shall be kept saturated by means of a mechanically operated sprinkling system. In place of the sprinkling system, at the Contractor's option, two layers of burlap covered with impermeable covering shall be used. The burlap shall be kept saturated with water. Plastic coated burlap may be substituted for one layer of burlap and impermeable covering.

The blankets shall be placed so that they are in contact with the edges of the concrete, and that portion of the material in contact with the edges shall be kept saturated with water.

(4) Membrane Curing Method. Membrane curing will not be permitted where a protective coat or waterproofing is to be applied or at areas where rubbing or a normal finish is required or at construction joints other than those necessary in pavement or base course. Concrete at these locations shall be cured by another method specified in this Section at no additional cost to the Department.

After the concrete has been finished and immediately after the water sheen has disappeared from the surface of the concrete, the surface shall be sealed with membrane curing compound of the type specified. The seal shall be maintained for the specified curing period. The edges of the concrete shall, likewise, be sealed immediately after the forms are removed. Two separate applications, applied at least one minute apart, each at the rate of not less than 0.16 L/m² (1 gal. per 250 sq. ft.) will be required upon the surfaces and edges of the concrete. These applications shall be made with the mechanical equipment specified. Type III compound shall be agitated immediately before and during the application.

At locations where the coating is discontinuous or where pin holes show or where the coating is damaged due to any cause and on areas adjacent to sawed joints, immediately after sawing is completed, an additional coating of membrane curing compound shall be applied at the above specified rate. The equipment used may be of the same type as that used for coating variable widths of pavement. Before the additional coating is applied adjacent to sawed joints, the cut faces of the joint shall be protected by inserting a suitable flexible material in the joint, or placing an adhesive width of impermeable material over the joint, or by placing the permanent sealing compound in the joint. Material, other than the permanent sealing compound, used to protect cut faces of the joint, shall remain in place for the duration of the curing period. In lieu of applying the additional coating, the area of the sawed joint may be cured according to any other method permitted.

If rain occurs before an application of membrane curing compound has dried, and the coating is damaged, another application shall be made in the same manner and at the same rate as the original coat. No additional compensation will be allowed the Contractor for materials or labor required to perform this work. The Engineer may order curing by another method specified, if unsatisfactory results are obtained with membrane curing compound; therefore, prior to starting paving, the

Contractor shall have available, at the site of the work, a supply of one of the other approved curing materials sufficient to cover one day's production.

(b) Removing and Replacing Curing Covering. When curing methods specified above in Article 1020.13(a), (1), (2) or (3) are used for portland cement concrete pavement, the curing covering for each day's paving shall be removed to permit testing of the pavement surface with a profilograph or straightedge, as directed by the Engineer.

Immediately after testing, the surface of the pavement shall be wetted thoroughly and the curing coverings replaced. The top surface and the edges of the concrete shall not be left unprotected for a period of more than 1/2 hour.

(c) Protection of Portland Cement Concrete, Other Than Structures, From Low Temperatures. When the official National Weather Bureau Forecast for the construction area predicts a low of 0 °C (32 °F.), or lower, or if the actual temperature drops to 0 °C (32 °F.), or lower, concrete less than 72 hours old shall be provided at least the following protection:

Minimum Temperature	Protection
-4 °C-0 °C	
(25 °F32 °F.)	2 layers of polyethylene sheeting or 1 layer of polyethylene and 1 layer of burlap, or 2 layers of waterproof paper.
Below -4 °C (25 °F.)	150 mm (6 inches) of straw covered with 1 layer of polyethylene sheeting or waterproof paper.

These protective covers shall remain in place until the concrete is at least 96 hours old. When straw is required on pavement cured with membrane curing compound, the compound shall be covered with a layer of burlap, polyethylene sheeting or waterproof paper before the straw is applied.

After September 15, there shall be available to the work within 4 hours, sufficient clean, dry straw to cover at least 2 days production of the mixer. Additional straw shall be provided as needed to afford the protection required. Regardless of the precautions taken, the Contractor shall be responsible for protection of the concrete placed and any concrete damaged by cold temperatures shall be removed and replaced by the Contractor at his/her own expense.

(d) Curing of Structures. In constructing grade separation structures, pump houses, retaining walls, bridges, and culverts, all concrete shall be cured for not less than 7 days nor more than 10 days after the concrete has been placed. Form removal may be allowed if continued curing procedures are implemented within 2 hours from the time of the start of the form removal.

### Portland Cement Concrete

When waterproofing is specified and when permitted according to Article 503.18, Asphalt Emulsion for Waterproofing may be used in lieu of other curing methods.

- (1) Curing Structure Footings and Foundations. Concrete may be cured by any of the methods listed under Article 1020.13(a). The use of water to inundate footings and foundations is permissible when approved by the Engineer, provided the water temperature can be maintained at 7 °C (45 °F.) or higher. Material and insulation used for curing or protection of the concrete may be removed the following day in areas where the Contractor must place forms to construct the successive pours of concrete.
- (2) Substructure Concrete. Forms on substructure units shall remain in place at least 24 hours after which the Contractor may remove forms according to Article 503.06 providing the remainder of the curing period is met by the use of one of the curing methods permitted under Article 1020.13(a).
- (3) Bridge Floors. The top surface of bridge floors placed between October 15 and April 15 of the following year shall be cured according to Article 1020.13(a)(3). Protective coat shall be applied to these floors according to Article 503.19.

The top surface of bridge floors placed between April 15 and October 15 of the same year shall be sprayed according to Article 1020.13(a)(4) and as specified with a Type II membrane curing compound immediately after the texturing operation is completed. As soon as the membrane curing compound has dried, the top surface shall then be immediately cured according to Article 1020.13(a)(3). Protective coat shall not be applied to these floors.

- (4) Superstructure (Except Bridge Floors). Concrete may be cured by Methods (1), (2) or (3) under Article 1020.13(a). On non-traffic surfaces which receive a normal finish, a linseed oil emulsion curing compound meeting the requirements of Article 1022.01(a) will be permitted provided it is applied with a mechanical sprayer meeting the requirements of Article 1101.09(b).
- (e) Protection of Structures From Low Temperatures. If temperatures below 7 °C (45 °F.) are forecast, protection methods will be required. Concrete shall not be placed when the air temperature is below 7 °C (45 °F.) and falling or below 4 °C (40 °F.) without permission of the Engineer. The temperature of plastic concrete shall be according to Article 503.07(b) at the time of placement. All exposed surfaces within the housing shall be cured according to the Index Table.

The Contractor shall provide means for checking the temperature of the surface of the concrete or air temperature within the housing during the protection period.

In constructing grade separation structures, pump houses, retaining walls, bridges and culverts having a waterway opening of more than 1 m<sup>2</sup> (10 sq. ft.), if the concrete is placed between December 1 and March 15 (winter period), the concrete shall be protected by Protection Method I or Protection Method II. In the construction of all structures not specified and all

incidental construction including footings and slope walls, concrete may be protected by Protection Method III. Concrete shall not be placed until the protection and facilities are approved by the Engineer.

The Contractor may be required to place concrete in the structures specified above during the winter period, when directed by the Engineer. If winter construction is specified, the Contractor shall proceed with the construction of these structures, including concrete, excavation, pile driving, steel erection, and all appurtenant work required for the complete construction of the structures during the winter period, except at times when weather conditions make such operations impracticable.

If the concrete is placed outside the winter period, and the temperature is below 7 °C (45 °F.) or at any time during the first 3 days falls below 7 °C (45 °F.), the concrete shall be protected according to Protection Method I or Protection Method II. In the construction of all structures not specified and all incidental construction, including footings and slope walls, concrete may be protected by Protection Method III. When Protection Method II is used to protect the concrete in bridge decks, the housing may enclose only the bottom and sides. The top surface shall be protected by Protection Method I.

(1) Protection Method I. The concrete shall be completely covered with insulating material such as fiberglass, rock wool, or other approved commercial insulating material having the minimum thermal resistance R, as defined in ASTMC 168, for the corresponding minimum dimension of the concrete unit being protected as shown in the following table:

150 or less (6 or less) R=: >150 to 300 (>6 to 12) R=: >300 to 450 (>12 to 18) R=: 450 (>over 18) R=:	10 3

The insulating material manufacturer shall clearly mark the insulating material with the thermal resistance R value.

The insulating material shall be completely enclosed on sides and edges with an approved waterproof liner and shall be maintained in a serviceable condition. Any tears in the liner shall be repaired in a manner approved by the Engineer.

On formed surfaces, the insulating material shall be attached to the outside of the forms with wood cleats or other suitable means to prevent any circulation of air under the insulation and shall be in place before the concrete is placed. The blanket insulation shall be applied tightly against the forms. The edges and ends shall be attached so as to exclude air and moisture. If the blankets are provided with nailing flanges, the flanges shall be attached to the studs with cleats. Where tie rods or reinforcement bars protrude, the areas adjacent to the rods or bars shall be adequately protected in a manner satisfactory to the Engineer. Where practicable, the insulation shall overlap any previously placed concrete by at least 300 mm (1 ft.). Insulation on the

underside of floors on steel members shall cover the top flanges of supporting members. On horizontal surfaces, the insulating material shall be placed as soon as the concrete has set so that the surface will not be marred and shall be covered with canvas or other waterproof covering. The insulating material shall remain in place for a period of 7 days after the concrete is placed.

The Contractor may remove the forms providing the temperature is  $2 \, ^{\circ}\text{C} \, (35 \, ^{\circ}\text{F.})$  and rising and the Contractor is able to wrap the particular section within 2 hours from the time of the start of the form removal. The insulation shall remain in place for the remainder of the 7 days curing period.

(2) Protection Method II. The concrete shall be enclosed in adequate housing and the air surrounding the concrete kept at a temperature of not less than 10 °C (50 °F.) nor more than 27 °C (80 °F.) for a period of 7 days after the concrete is placed. Concrete shall not be placed until the protection and facilities for heating have been approved by the Engineer. All exposed surfaces within the housing shall be cured according to the Index Table.

The Contractor shall provide adequate fire protection where heating is in progress and such protection shall be accessible at all times. The Contractor shall maintain labor to keep the heating equipment in continuous operation.

At the close of the heating period, the temperature shall be decreased to the approximate temperature of the outside air at a rate not to exceed 8 °C (15 °F.) per 12 hour period, after which the housing may be removed. The surface of the concrete shall be permitted to dry during the cooling period.

(3) Protection Method III. As soon as the surface is sufficiently set to prevent marring, the concrete shall be covered with 300 mm (12 inches) of loose, dry straw followed by a layer of impermeable covering. The edges of the covering shall be sealed to prevent circulation of air and prevent the cover from flapping or blowing. The protection shall remain in place until the concrete is 7 days old. If construction operations require removal, the protection removed shall be replaced immediately after completion or suspension of such operations. This method may not be used on slope walls when structural steel or structural concrete is in place above.

# 1020.14 Temperature Control for Placement.

(a) Portland Cement Concrete other than Structures. The temperature of mixed concrete immediately before placing, shall be not less than 10 °C (50 °F.) nor more than 32 °C (90 °F.). Aggregates and water shall be heated or cooled as necessary to produce concrete within these temperature limits.

When the temperature of the plastic concrete reaches 30 °C (85 °F.), an approved retarding admixture shall be used or the approved water reducing admixture in use shall have its dosage increased by 50 percent over the dosage recommended by the Approved Admixtures list for the temperature experienced. This requirement may be waived by the Engineer when fly

ash compensated mixtures are used.

Plastic concrete temperatures up to 35 °C (96 °F.), as placed, may be permitted provided jobsite conditions permit placement and finishing without excessive use of water on and/or overworking of the surface. The occurrence within 24 hours of unusual surface distress shall be cause to revert to a maximum 32 °C (90 °F.) plastic concrete temperature.

Unless authorized in writing by the Engineer, mixing and concreting operations shall be discontinued when a descending air temperature in the shade and away from artificial heat reaches 5  $^{\circ}$ C (40  $^{\circ}$ F.) and not resumed until an ascending air temperature in the shade and away from artificial heat reaches 2  $^{\circ}$ C (35  $^{\circ}$ F.).

When placing of concrete is authorized during cold weather, the Engineer may require the water and/or the aggregates to be heated to not less than 20 °C (70 °F.) nor more than 65 °C (150 °F.). The aggregates may be heated by either steam or dry heat prior to being placed in the mixer. The apparatus used shall heat the mass uniformly and shall be so arranged as to preclude the possible occurrence of overheated areas which might damage the materials. No frozen aggregates shall be used in the concrete.

(b) Temperature Control for Structures. Placing of concrete will be permitted only under the following conditions:

The temperature of the concrete mixture as placed in the forms shall be not less than 10 °C (50 °F.) nor more than 30 °C (90 °F.). When insulated forms are used, the temperature of the concrete mixture shall not exceed 25 °C (80 °F.) and if it is determined by the Engineer that heat of hydration might cause excessive temperatures in the concrete, the concrete shall be placed at a lower temperature between 10 °C (50 °F.) and 15 °C (60 °F.), as directed by the Engineer. When concrete is placed in contact with previously placed concrete, the temperature of the mixed concrete may be increased as required to offset anticipated heat loss.

When the temperature of the plastic concrete reaches 30 °C (85 °F.), an approved retarding admixture shall be used or the approved water reducing admixture in use shall have its dosage increased by 50 percent over the dosage recommended by the Approved Admixtures list for the temperature experienced. This requirement may be waived by the Engineer when fly ash compensated mixtures are used.

(c) Temperature. The concrete temperature shall be determined according to ASTM C 1064.

## **SECTION 1021. CONCRETE ADMIXTURES**

**1021.01 General.** Admixtures shall be furnished in liquid form ready for use. The admixtures may be delivered to the job in the manufacturer's original containers, bulk tank trucks or such containers or tanks as are acceptable to the Engineer. Delivery shall be accompanied by a ticket which clearly identifies the manufacturer and trade name of the material. In all cases, containers remaining on the job shall be readily identifiable to the satisfaction of the Engineer as to manufacturer and trade name of the material they contain.

When AASHTO M 194 is specified, the test mixture shall contain a cement content of 335 kg/m<sup>3</sup> (5.65 cwt. per cu. yd.).

When ASTM C 672 is specified, the test mixture shall contain a coarse aggregate meeting the requirements of AASHTO M 43, gradation 67, and a cement content of 335 kg/m $^3$  (5.65 cwt. per cu. yd.), the deicing agent shall be rock salt (sodium chloride) applied at a rate of 0.001 g/mm $^2$  (2/3 gram per sq. inch) of surface area. Tests shall be continued until 60 cycles have been completed. 200 mm x 250 mm (8 x 10") glossy photos of each specimen will be required for evaluation by the Engineer, at the conclusion of testing.

Prior to approval of a product, 2 copies of a report prepared by a laboratory regularly inspected by the Cement and Concrete Reference Laboratory (CCRL) of the National Institute of Standards and Technology (NIST) shall be forwarded to the Engineer of Materials and Physical Research. The report shall show the results of physical tests using materials and methods specified on a "test" concrete and a "reference" concrete, together with a certification that no changes have been made in the formulation of the material since the performance of the tests. Prior to the final approval of any brand or type of admixture, the Engineer may conduct all or part of the applicable tests on a sample that is representative of the material to be furnished. The manufacturer shall submit to the Engineer a sample of not less than 4 L (1 gal.). A field experimental section may also be required.

If the admixture previously has been approved by the Engineer, approval of its use will be granted upon the certification by the manufacturer that the admixture is of the same formulation as that previously approved. If minor changes have been made, the certification shall state that the admixture is essentially the same as previously approved, and the Engineer may conduct such tests as deemed desirable to check the properties of the material before approval is granted.

The manufacturer shall submit certification giving the average and manufacturing range of specific gravity at 25 °C (77 °F.), the average and manufacturing range of solids in the solution based on the residue dried for 17 hours ( $\pm$  15 minutes) at 105 °C (221 °F.), the average and manufacturing range of pH, and including an infrared spectrophotometer trace of current production material. The certification further shall state that, for all except chloride-based accelerators, the admixture contains no more than 0.3 percent chloride by mass. The material shall not be used until it has been shown to conform with the requirements.

Either prior to or after the start of construction, the Engineer may conduct further tests upon the admixture selected by the Contractor to assure conformity with the requirements. Any admixture failing to meet the requirements will be rejected.

**1021.02 Air-Entraining Admixtures.** Air-entraining admixtures shall conform to the requirements of AASHTO M 154, as modified by Note 1 in Article 1021.03(b). In the event that the air-entraining admixture is an aqueous solution of Vinsol resin that has been neutralized with sodium hydroxide (caustic soda), and provided that the manufacturer so certifies, tests for compliance with the requirements may be waived by the Engineer. In certification, the manufacturer shall show complete information with respect to the formulation of the solution, including the number of parts of Vinsol resin to each part of sodium hydroxide. Before the approval of its use is granted, the Engineer will test the solution for its air-entraining quality in comparison with a solution prepared and kept for that purpose, and a sample of not less than 1 L (1 qt.) shall be submitted for this test.

\_ 1021.03 Retarding and Water-Reducing Admixtures. The admixture shall comply with the following requirements:

- (a) The retarding admixture shall comply with the requirements of AASHTO M 194, Type D, and ASTM C 672, in addition to Note 1 in (b).
- (b) The water reducing admixture shall comply with the requirements of AASHTO M 194, Type A, and ASTM C 672.
  - Note 1. AASHTO T 161, Procedure B, shall be used.
- (c) High Range Water Reducing or Retarding Admixture. The high range water reducing or retarding admixture shall comply with the requirements of AASHTO M 194, Type F or Type G, respectively.

Care shall be taken that water contents are not reduced to levels which will restrict cement hydration. Water-cement ratios shall not be lower than 0.32.

High range water reducers or retarders may be used as plasticizing agents to obtain slumps outside those specified, subject to the following restrictions:

Water-cement ratios shall not exceed 0.42, 0.44, and 0.46 for fine aggregate Types A, B and C, respectively. The liquid admixture shall be counted as water in the calculation of the water-cement ratio.

An initial slump of 40 mm (1 1/2 inches) to 50 mm (2 inches) is recommended prior to addition of the high range admixture. Final slump shall be no greater than is necessary for proper placement and compaction and in no case shall exceed 180 mm (7 inches) after addition of the high range admixture.

Air tests will be performed after the addition of the admixture.

The high range admixture shall be added at the jobsite unless otherwise directed by the Engineer. High range admixtures, at a dosage rate not to exceed 40 percent of the original amount used, may be used to retemper concrete, provided set times are not unduly affected.

With permission of the Engineer, admixtures compatible with the high range admixture may be used concurrently to facilitate placement and/or strength gain and/or to control set times.

**1021.04 Set Accelerating Admixtures.** The admixture shall comply with the requirements of AASHTO M 194, Type C or Type E, and ASTM C 672 in addition to Note 1 in Article 1021.03(b).

### SECTION 1022, CONCRETE CURING MATERIALS

- **1022.01 Membrane Curing Compound.** Membrane curing compound shall be one of the following 3 types. The type used shall be that stipulated in the contract or authorized by the Engineer.
  - Type I. The curing compound shall be a clear transparent membrane without a fugitive dye.
  - Type II. The curing compound shall be a clear translucent membrane containing a fugitive dye. It shall not contain oils, waxes or other materials which would tend

to prevent bonding of bituminous concrete surfaces.

Type III. The curing compound shall be white pigmented. It shall contain finely divided white pigment and vehicle, premixed for immediate use without alteration. When applied to concrete at the specified rate of application, the compound shall exhibit a daylight reflectance of not less than 60 percent of that of magnesium oxide.

Each type of membrane curing compound shall conform with the following:

- (a) The curing compound shall be of a consistency suitable for spraying, shall be relatively nontoxic, and shall adhere satisfactorily to a vertical or horizontal surface of damp concrete when applied immediately after the disappearance of surface water sheen. It shall not react harmfully with the components of concrete. The resulting film shall be continuous, uniform, moisture impermeable, free from pinholes, and shall not peel.
- (b) The curing compound, when applied to the surface of the mortar specimens in the determination of water loss, as specified, shall dry to touch in one hour and shall dry through in not more than 4 hours. When used in the field, it shall show drying properties satisfactory to the Engineer.
- (c) The curing compound shall not darken the natural color of the concrete. The fugitive dye when required shall have a color strength sufficient to render the film distinctly visible for at least one hour after application. The color of the fugitive dye shall disappear within 7 days after application.
- (d) The curing compound shall be of such viscosity that it may be readily applied by approved pressure spraying equipment at temperatures above 4 °C (40 °F.).
- (e) The curing compound shall be delivered to the job only in the manufacturer's original container, which shall be marked with the manufacturer's name, trade name of the material, and number or symbol with which test samples may be correlated.
  - Curing compounds which are flammable shall be so designated on the container.
- (f) Specimens used for determining moisture loss will be made and tested according to AASHTO T 155, except as follows:
  - (1) The molds for the specimens will be standard pie tins having the shape of the frustum of a right cone, 135 mm (5 3/8 inches) in diameter at the top, 100 mm (4 inches) in diameter at the bottom and 24 mm (15/16 inch) in depth, or any other size and shape found necessary or desirable. The use of control specimens may be omitted.
  - (2) The flow of the mortar used in the specimens will be optional, but will be not greater than that specified by the AASHTO method. The sand used in the mortar will be natural sand conforming with the gradation specified by the AASHTO method. The mortar may be machine mixed, and the molds will be filled in one layer and struck off even with the top of the rim of the mold.
  - (3) The water lost from the specimens prior to the application of the curing compound will not be included in the results reported.

(4) Duplicate sets of specimens will be made. One set will be tested in the curing cabinet adopted for this purpose by the Department. The other set will be tested by placing each specimen, immediately after application of the curing compound, under a reflector spot lamp for a period of 5 hours. The distance between the lamps and the specimens will be adjusted to produce a temperature of 49 °C ± 2 ° (120 °F. ± 3°) in the dry mortar specimens not coated with curing compound, kept for the purpose of calibrating the position of the lamps. During the test, air at room temperature will be blown constantly across the surface of the specimens.

In applying the curing compound to the surface of the specimens, the rate of spraying will be 200 mL/m<sup>2</sup> (1 gal./200 sq. ft.) of surface, and the nozzle of the spray will be held from 125 to 150 mm (5 to 6 inches) above the surface of the specimens.

When tested in the curing cabinet, the average moisture loss of the specimens shall be not more than the following amounts of moisture per mm<sup>2</sup> (square inch) of exposed surface:

At 24 hours	.00012 g	(0.075 gram)	)
At 72 hours	.00023 g	(0.150 gram)	)
At 7 days	.00047 g	(0.300 gram)	)

When tested under the reflector spot lamps for a period of 5 hours, the average moisture loss of the specimens shall be not more than 0.00016 g/mm<sup>2</sup> (0.100 gram per square inch) of exposed surface.

(g) All curing compounds will be tested by the Engineer. A sample of at least 4 L (1 gal.) of any curing compound proposed for use shall be sent directly to the Engineer for preliminary tests at least 30 days before the proposed date of use. Curing compounds which are flammable shall be so designated on the container.

No shipment of curing compound will be accepted for use unless it conforms to the requirements of the Specifications as indicated by the results of the tests of samples taken by an authorized representative of the Department from the material actually shipped.

No curing compound shall be used until the Contractor has been notified by the Engineer that it meets these requirements.

- **1022.02 Burlap Curing Blankets.** Burlap blankets shall be made from whole stock widths of new burlap and shall be 600 mm (2 ft.) longer than the width of the pavement. The burlap shall be free from substances which may be deleterious to freshly laid concrete. Sacks or burlap reclaimed from uses other than curing shall not be used. Reused burlap shall be in a condition satisfactory to the Engineer. The burlap shall conform to the following requirements:
  - (a) Mass per m<sup>2</sup> (sq. yd.), not less than 305 g (9 oz).
  - (b) Ash (based on dry mass), not more than 3.0%.
  - (c) The burlap shall be composed of not less than 95.0% jute and manila fibers.

**1022.03 Waterproof Paper Blankets.** Waterproof paper blankets shall meet the requirements of AASHTO M 171 and the following:

- (a) General Requirements. The paper composing the blankets shall be 100% sulphate kraft. The color of the top sheet shall be that which the paper industry terms "white" for this grade of paper and shall meet the approval of the Engineer.
  - Blankets shall be reinforced by jute, cotton, or glass yarn of satisfactory mass (weight), completely embedded in the bituminous cement, running in both longitudinal and transverse directions not more than 15 mm (1/2 inch) apart and crossing at approximately right angles. Unspun fibers may be used, in which case approximately 500 m/m² (1400 ft. per sq. yd.) shall be embedded in the bituminous cement in a manner that will provide adequate reinforcing in both longitudinal and transverse directions. A suitable bituminous cement shall be used.
- (b) Impermeability. When tested by the applicable parts of the method in Article 1022.01, mortar specimens having the surface sealed with samples of impermeable paper blanket proposed for use shall show moisture losses no greater than specified.
- (c) Tensile Strength. The specimens to be tested wet shall be immersed in water having a temperature between 21 °C and 24 °C (70 °F. and 75 °F.) for a period of one hour immediately prior to testing.
- 1022.04 White Polyethylene Sheeting. White polyethylene sheeting shall be of single sheet stock manufactured from virgin resin and shall contain no scrap or additives. It shall be not less than 100  $\mu$ m (4 mils) in thickness; shall be free from visible defects and of uniform appearance; and shall not easily tear, puncture or otherwise become unfit for use. Its color shall be white and shall meet the approval of the Engineer.

The sheeting shall meet the following physical requirements:

- (a) Impermeability. When tested by the applicable parts of the method prescribed in Article 1022.01, mortar specimens having the surface sealed with samples of the sheeting proposed for use shall show moisture losses no greater than specified.
- (b) Tensile Strength and Elongation. When tested according to ASTM D 882, Method B, the polyethylene sheeting shall have a tensile strength of not less than 11.7 MPa (1700 psi) in the machine direction and 8.3 MPa (1200 psi) in the transverse direction. The elongation shall not be less than 225 percent in the machine direction and 350 percent in the transverse direction. Tests shall be made at a temperature between 22 °C and 25 °C (72 °F. and 78 °F.).
- **1022.05 Burlap-Polyethylene Blanket.** The burlap and polyethylene shall be bonded together so that the blanket acts as a unit. The burlap shall conform to the requirements of Article 1022.02 The polyethylene sheeting shall conform to the requirements of Article 1022.04 When tested by the applicable parts of the method prescribed in Article 1022.01, mortar specimens having the surface sealed with samples of the blanket proposed for use shall show moisture losses no greater than specified.

### SECTION 1023. PROTECTIVE COAT

**1023.01 Requirements.** Protective coat shall conform with the requirements of AASHTO M 233 except the protective coat shall have a nonvolatile range of 53 to 57 percent and the petroleum spirits used in the production of the protective coat shall be Type I conforming to the requirements of ASTM D 235 with a maximum copper corrosion rating of 2.

### **SECTION 1024. NONSHRINK GROUT**

1024.01 Requirements. Nonshrink grout shall be a flowable nonmetallic grout and nonshrink when tested according to the applicable portions of the Corps of Engineers "Specification for Nonshrink Grout", CRD-C621. The maximum expansion allowable in this test at 3, 14 and 28 days is 0.4%. The expansion at 3 and 14 days shall not be greater than the expansion at 28 days. The grout shall have a compressive strength of not less than 20 MPa (3000 psi) at an age of 24 hours when tested using applicable portions of ASTM C 109M (C 109). The compressive strength specimens shall be produced from a mixture of the dry grout and sufficient water to produce a flowable mixture. The initial set shall not be less than 60 minutes when tested under CRD-C82, "Method of Test for Time of Setting of Grout Mixtures," Corps of Engineers. The resistance of the grout to freeze thaw shall be such that it maintains a relative dynamic modulus of elasticity of not less than 80% after 300 cycles when tested according to AASHTO T 161, Procedure B. The grout product may be accepted under certification that it meets the above requirements; however, the Department retains the right to perform any or all of the tests as a condition of approval.

#### SECTION 1025. EPOXY CONCRETE MATERIALS

**1025.01 Adhesive.** The epoxy concrete adhesive shall be a 2-component, epoxy-resin system for use in bonding freshly mixed concrete to hardened concrete. The epoxy concrete adhesive shall conform to the requirements of ASTM C 881, Type V, Grade 2, Class B or C. The class supplied shall be governed by the range of temperatures for which the material is to be used.

The 2-component adhesive shall be furnished by the manufacturer in containers individually marked to clearly identify each component. The epoxy adhesive shall be packaged in a kit with each component in a separate container. The containers of each kit shall be filled with the adhesive components in exact mixing proportions and one container shall be large enough to mix both of the components. The size of the kit shall be the total volume of the mixed adhesive which shall be 5 L (1 gal.) or 20 L (5 gals.) as specified. The manufacturer shall supply mixing instructions.



The adhesive shall be supplied as an unfilled, clear resin system.

Prior to approval and use of the 2-component adhesive materials, the Contractor shall submit a notarized certification by the formulator of these materials, stating that they meet these requirements.

**1025.02 Epoxy Mortar.** The epoxy mortar shall consist of a 2-component epoxy-resin system suitably mixed with an aggregate of a type and gradation recommended by the manufacturer. The mortar shall have an initial cure period of not more than 24 hours.

The epoxy mortar shall be non-sagging and suitable for placement in vertical and overhead positions and shall be capable of bonding to damp concrete surfaces. The resin shall contain a white pigment and the hardener shall contain a black pigment in such proportions that the resulting mixture is concrete gray.

The binder in the epoxy mortar shall be a 2-component, epoxy-resin bonding system conforming to the requirements of ASTM C 881, Type III, Grade 3, Class A, B or C. The Class supplied shall be governed by the range of temperature for which the material is to be used.

The prime for bonding the epoxy mortar to the concrete shall be a 2-component, epoxy-resin system conforming to the requirements of ASTM C 881, Type III, Grade 1, Class A, B or C.

The system furnished shall be compounded for and specifically recommended by the manufacturer for the use specified. Prior to approval and use of the product furnished, the Contractor shall submit a notarized certification by the formulator of these materials, stating that they meet these requirements.

The epoxy adhesive shall be packaged in a kit with each component in a separate container. The containers of each kit shall be filled with the adhesive components in exact mixing proportions and one container shall be large enough to mix both of the components. The size of the kit shall be the total volume of the mixed adhesive which shall be 4 L (1 gal.) or 20 L (5 gals.) as specified.

**1025.03 Epoxy Bonding Compound.** The epoxy bonding compound used for grouting and sealing the cracks in the concrete shall be a 2-component, epoxy-resin bonding system conforming to the requirements of ASTM C 881, Type IV, Grade 1, Class A, B or C. The class supplied shall be governed by the range of temperature for which the material is to be used. The bonding compound shall be supplied as an unfilled, clear resin system.

The system furnished shall be compounded for and specifically recommended by the manufacturer for grouting non-moving damp cracks and voids in concrete. The 2 components shall be furnished in containers individually marked to clearly identify each component.

The epoxy adhesive shall be packaged in a kit with each component in a separate container. The containers of each kit shall be filled with the adhesive components in exact mixing proportions and one container shall be large enough to mix both of the components. The size of the kit shall be the total volume of the mixed adhesive which shall be 4 L (1 gal.) or 20 L (5 gals.) as specified. The manufacturer shall supply mixing instructions, specifying particularly how the components are to be combined in parts by mass (weight) or parts by volume.

Prior to approval and use of the product furnished, the Contractor shall submit a notarized certification by the formulator of these materials, stating that they meet these requirements.

**1025.04 Epoxy Grout.** The epoxy grout shall be a 2-component, epoxy-resin bonding system conforming to the requirements of ASTM C 881, Type IV, Grade 2, Class B or C. The Class supplied shall be governed by the range of temperatures for which the material is to be used. The resin shall contain a white pigment and the hardener shall contain a black pigment in such proportions that the resulting mixture is concrete gray.

The 2-component, epoxy-resin grout shall be furnished by the manufacturer in premeasured, preassembled cartridges suitably designed for mixing and application

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of the grout or in containers individually marked to clearly identify each component.

The epoxy adhesive shall be packaged in a kit with each component in a separate container. The containers of each kit shall be filled with the adhesive components in exact mixing proportions and one container shall be large enough to mix both of the components. The size of the kit shall be the total volume of the mixed adhesive which shall be 4 L (1 gal.) or 20 L (5 gals.) as specified. Regardless of how it is furnished, the manufacturer shall supply mixing instructions.

Prior to approval and use of the epoxy-resin grout, the Contractor shall submit a notarized certification by the formulator, stating that the epoxy-resin grout meets these requirements.

1025.05 Reserved.

### SECTION 1026. BRIDGE SEAT SEALER

**1026.01 General.** Sealer types shall be according to the listing in AASHTO M 224 and additional types will be considered for use. The Department will maintain an approved list.

The sealer shall have a clear or amber color when dry.

The sealer shall be tested according to Illinois Modified ASTM C 672. The average visual rating of the test specimens treated with sealer, divided by, the average visual rating of the untreated test specimens shall not exceed 0.80 after 60 cycles.

### SECTION 1027, CHEMICAL ADHESIVE

**1027.01 Chemical Adhesive Resin System.** The chemical adhesive resin system shall consist of a 2-part, fast-setting resin and filler/hardener. Materials shall be according to the Bureau of Materials and Physical Research's Policy memorandum "Chemical Adhesive Acceptance Procedures," and be listed on the Department's approved list.

### MASONRY AND DRAINAGE ITEMS

# SECTION 1040. DRAIN PIPE, TILE, TUBING, DRAINAGE MAT AND WALL DRAIN

- **1040.01 Drain Tile.** Drain tile shall conform to the requirements of ASTM C 4. The tile furnished shall be that designated as Heavy-Duty Drain Tile. The maximum length of the units shall be 600 mm (24 inches).
- **1040.02 Clay Pipe.** Extra strength clay pipe, extra strength perforated clay pipe and clay sewer pipe shall conform to the requirements of ASTM C 700.
- **1040.03** Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe. These pipes shall conform to the requirements of AASHTO M 170M (M 170) Classes I to V, Tables I to V, except that the use of elliptical reinforcement in circular pipe will not be permitted and the aggregate shall conform to the requirements of Articles 1003.02 and 1004.02 with the exception of gradation. When the concrete has attained the required strengths, but not prior to 4 days after casting, the units may be loaded, shipped and used. Chert gravel may be used based on past in-service satisfactory performance in the environment in which the product is to be used.
- **1040.04 Concrete Sewer, Storm Drain, and Culvert Pipe.** These pipes shall conform to the requirements of AASHTO M 86M (M 86), except that the aggregate shall conform to the requirements of Articles 1003.02 and 1004.02 with the exception of gradation. The pipe furnished shall be of the class designated. When the concrete has attained the required strengths, but not prior to 4 days after casting, the units may be loaded, shipped and used. Chert gravel may be used on past in-service satisfactory performance in the environment in which the product is to be used.
- **1040.05** Reinforced Concrete Elliptical Culvert, Storm Drain, and Sewer Pipe. These pipes shall conform to the requirements of AASHTO M 207M (M 207) except that the aggregate shall conform to the requirements of Articles 1003.02 and 1004.02 with the exception of gradation. When the concrete has attained the required strength, but not prior to 4 days after casting, the units may be loaded, shipped and used. Chert gravel may be used based on past in-service satisfactory performance in the environment in which the product is to be used.
- **1040.06 Concrete Drain Tile.** Concrete drain tile shall conform to the requirements of AASHTO M 178M (M 178) except that the minimum crushing strength shall be 20.5 kN/m (1400 lbs. per ft.) and the aggregate shall conform to the requirements of Articles 1003.02 and 1004.02 with the exception of gradation. When the concrete has attained the required strength, but not prior to 4 days after casting, the units may be loaded, shipped and used. Chert gravel may be used based on past in-service satisfactory performance in the environment in which the product is to be used.
- **1040.07** Reinforced Concrete Arch Culvert, Storm Drain, and Sewer Pipe. These pipes shall conform to the requirements of AASHTO M 206M (M 206) except that the aggregate shall conform to the requirements of Articles 1003.02 and 1004.02 with the exception of gradation.
- 1040.08 Acrylonitrile-Butadiene-Styrene (ABS) and Polyvinyl Chloride (PVC) Composite Sewer Piping. These pipes shall conform to the requirements of AASHTO M 264. Acceptance testing of ABS and PVC composite sewer piping shall be accomplished during the same construction season in which it is installed.



**1040.09 Perforated Polyvinyl Chloride (PVC) Pipe.** This pipe shall conform to AASHTO M 278 except that it shall be made of PVC plastic having a minimum cell classification of 12454-C according to ASTM D 1784, four rows of perforations at 50-mm (2-inch) centers will be acceptable for 300-mm (12-inch) and 375-mm (15-inch) diameter pipes, and shall have a minimum pipe stiffness of 317 kPa (46 lbs./inch/inch) at 5 percent deflection.



1040.10 Polyvinyl Chloride (PVC) Pipe. This pipe shall conform to AASHTO M 278 or ASTM F 679 except that it shall be made of PVC plastic having a minimum cell classification of 12454-C, as defined in ASTM D 1784, shall have a minimum pipe stiffness at 5 percent deflection of 317 kPa (46 lbs./inch/inch) and shall withstand flattening to where the distance between the plates is twice the wall thickness plus 5 percent of the inside diameter. Acceptance testing of PVC pipe and fittings shall be accomplished during the same construction season. The section properties shall be according to AASHTO's Section 18. This pipe will require the manufacturer's certification that the material meets AASHTO's Section 18 properties.



1040.11 Perforated Corrugated Polyethylene (PE) Tubing. When used for backslope drains tubing shall conform to the requirements of AASHTO M 252. When used for underdrain, this tubing shall according to AASHTO M 252 Corrugated Polyethylene Drainage Tubing, shall have a minimum cell classification of PE 334413 C according to ASTM D 3350, shall have a minimum pipe stiffness of 317 kPa (46 lbs./inch/inch) at 5 percent deflection and shall be capable of 60 percent vertical deflection in parallel plate loading without splitting or cracking. The supplier of PE tubing for underdrain under this specification shall certify that the resin used in the manufacture meets or exceeds the minimum cell classification requirements. PE tubing and fittings shall not be exposed to direct sunlight for more than 6 months. Fabric envelope materials shall be stored in UV-resistant bags until just prior to installation. Acceptance testing of PE tubing shall be accomplished in the same construction season in which it is installed.



**1040.12** Corrugated Polyethylene (PE) Tubing. When used for backslope drains, this tubing shall conform to the requirements of AASHTO M 252. When used for underdrain, this tubing shall be according to AASHTO M 252, shall have a minimum cell classification of PE 334413-C according to ASTM D 3350, shall have a minimum pipe stiffness of 317 kPa (46 lbs./inch/inch) at 5 percent deflection and shall be capable of 60 percent vertical deflection in parallel plate loading without splitting or cracking. The supplier of PE tubing for underdrain shall certify that the resin used in the manufacture meets or exceeds the minimum cell classification requirements. PE tubing and fittings shall not be exposed to direct sunlight for more than 6 months. Acceptance testing of PE tubing shall be accomplished in the same construction season in which it is installed.

**1040.13 Drainage Mat Underdrain.** Drainage mat underdrain shall be on the Department's approved list. Drainage mat underdrain shall be a flexible rectangular hollow mat consisting of a supporting drainage core of the width shown on the plans and a nominal of 25 mm (1.0 inch) thick, encased in and/or bonded to an approved geotechnical fabric envelope weighing not less than 135 g/m² (4.0 oz. per sq. yd.) fitting snugly around the core. The flow rate of the core shall be not less than 60 L (16 gals.) per minute at a hydraulic gradient of 0.1, 30 mm (1.20 inches) of total head, nominal width and length of 300-mm (12-inch) specimen, when subjected to a normal stress of 200 kPa (30 psi) according to ASTM D 4716. Closed-cell foam rubber layers shall be used to model soil adjacent on both sides of the specimen. The compressive strength of the drainage mat underdrain shall be a minimum of 215 kPa (4500 lbs. per sq. ft.) with a maximum deflection of 20 percent, when tested between parallel plates according to ASTM D 695M (D 695) with the modification of

6-mm (1/4-inch) thick rubber cushions having standard hardness of  $80\pm10$  Shore A Durometer above and below the specimen. The drainage core shall be fabricated of polyethylene with a minimum cell classification of PE 112110 or better according to ASTM D 3350, or of PVC 12353-C or better according to ASTM D 1784, or other approved material. Drainage mat underdrain shall be furnished with approved fittings to connect with the type of pipe underdrain (special) used. The manufacturer of the drainage mat underdrain shall certify that the flow rate specified according to ASTM D 4716 is met and the resin used in the manufacture of the drainage core meets or exceeds the minimum cell classification requirements.

**1040.14** Perforated Corrugated Polyvinyl Chloride (PVC) Pipe With A Smooth Interior. This pipe shall conform to the requirements of ASTM F 949. In addition, the top centerline of the pipe shall be marked so that it is readily visible from the top of the trench before backfilling, and the upper ends of the slot perforations shall be a minimum of 10° below the horizontal. Acceptance testing of PVC pipe and fittings shall be accomplished during the same construction season in which they are installed.



- 1040.15 Corrugated Polyvinyl Chloride (PVC) Pipe With A Smooth Interior. This pipe shall conform to the requirements of ASTM F 949. Acceptance testing of PVC pipe and fittings shall be accomplished during the same construction season in which they are installed. Pipe shall have a minimum cell classification of 12454 B or C as defined in ASTM D 1784. The section properties shall be according to AASHTO's Section 18. This pipe will require the manufacturer's certification that the material meets AASHTO's Section 18 properties.
- **1040.16 Polyethylene (PE) Pipe with a Smooth Interior.** This pipe shall be according to ASTM F 714 (DR 32.5) with a minimum cell classification of PE 335434 as defined in ASTM D 3350. The section properties shall be according to AASHTO's Section 18. This pipe will require the manufacturer's certification that the material meets AASHTO's Section 18 properties. The manufacturer shall also certify that the resin used in the manufacturer of the pipe meets or exceeds the minimum cell classification requirements. Storage and handling shall be according to the manufacturer's recommendations except in no case shall the pipe be exposed to direct sunlight for more than 6 months. Acceptance testing of this pipe shall be accomplished during the same construction season in which it is installed.
- **1040.17** Reinforced Plastic Mortar (RPM) Pipe. This pipe shall be according to ASTM D 3262 and shall have approved inverted bell and spigot joints with elastomeric seals conforming to ASTM F 477.
- **1040.18** Polyethylene (PE) Profile Wall Pipe Liner. Polyethylene (PE) Profile Wall Pipe Liner shall conform to the requirements of ASTM F 667 for sizes 200 mm to 375 mm (8 inches to 15 inches), and to ASTM F 894 for sizes 450 to 1050 mm (18 to 42 inches). All sizes shall have wall construction that presents essentially smooth internal and external surfaces. The pipe liner shall have a minimum pipe stiffness of 320 kPa (46 psi) at 5 percent deflection.



**1040.19** Perforated Corrugated Polyethylene (PE) Pipe With a Smooth Interior. When used for backslope drains, this pipe shall conform to the requirements of AASHTO M 252. When used for underdrains, this pipe shall be according to AASHTO M 252, shall have a minimum cell classification of PE 334413 according to ASTM D 3350, shall have a minimum pipe stiffness of 317 kPa (46 lbs./inch/inch) at 5 percent deflection, and shall be capable of 60 percent vertical deflection in parallel plate loading without splitting or cracking. The supplier of PE pipe for underdrains under this specification shall certify that the resin used in the manufacture meets or

exceeds the minimum cell classification requirements. PE pipe and fittings shall not be exposed to direct sunlight for more than 6 months. Fabric envelope materials shall be stored in UV-resistant bags until just prior to installation. Acceptance testing of PE pipe shall be accomplished in the same construction season in which it is installed.



1040.20 Corrugated Polyethylene (PE) Pipe With a Smooth Interior For Drains and Underdrains. When used for backslope drains, this pipe shall be according to the requirements of AASHTO M 252. When used for underdrains, this pipe shall conform to the requirements of AASHTO M 252, shall have a minimum cell classification of PE 334413 as defined in ASTM D 3350, shall have a minimum pipe stiffness of 317 kPa (46 lbs./inch/inch) at 5 percent deflection and shall be capable of 60 percent vertical deflection in parallel plate loading without splitting or cracking. The supplier of PE pipe for underdrains under this specification shall certify that the resin used in the manufacture meets or exceeds the minimum cell classification requirements. PE pipe and fittings shall not be exposed to direct sunlight for more than 6 months. Acceptance testing of PE pipe shall be accomplished in the same construction season in which it is installed.

1040.21 Geocomposite Wall Drain. Geocomposite wall drain shall be a flexible geocomposite consisting of a supporting structure or core, the soil side of which is bonded to an approved geotextile weighing not less than 120 g/m<sup>2</sup> (3.5 ounces per sq. yd.). The drainage core shall provide support to and be bonded to the geotextile at intervals not exceeding 30 mm (1 1/8 inch) in any direction, and shall permit unobstructed flow through not less than 75 percent of the geotextile. The flow rate of the core shall not be less than 125 L per min. per m (10 gals. per min. per ft.) at a hydraulic gradient of 1.0 when subjected to a normal pressure on the soil side face of 285 kPa (6,000 lbs. per sq. ft.). When tested in a sand box according to the Department's method at 285 kPa (6,000 lbs. per sq. ft.), the core deflection shall not exceed 20 percent. the core shall be fabricated of polyethylene with a minimum cell classification of PE 112110 according to ASTM D 3350 or other approved material. Geocomposite wall drain shall be furnished with approved fittings to connect with outlet pipes and weep holes, shall have suitable approved splices and end, top and bottom caps to prevent the intrusion of backfill material into the core, and shall have approved fastening systems to secure the wall drain to the wall.



**1040.22** Corrugated Polyethylene (PE) Pipe with a Smooth Interior. This pipe shall be according to AASHTO M 294, 300 to 900 mm (12 to 36 inch) diameter, shall have a minimum cell classification of PE 325410 C as defined in ASTM D 3350 except as noted. The maximum melt index shall be no greater than 0.6. The pipe shall be Type S. The average pipe stiffness shall be according to AASHTO M 294 but shall equal or exceed the minimum pipe stiffness value for each size of pipe. The minimum wall thickness will be as follows:

Art. 1040.22 Drain Pipe, Tile, Tubing, Drainage Mat and Wall Drain

Nominal Size	Min. ID	Max. O.D.	Min. Wall Area	Min. C	Min. Mom. of Inertia	Min. Pipe Stiff.	Min. Wall Thick.
mm	mm	mm	mm²/mm	mm	mm <sup>4</sup> /mm	kPa	mm
300 375 450 600 750 900	300 376 450 600 749 902	373 457 546 729 925 1080	3.2 4.0 5.0 6.6 8.3 9.5	8.9 11.4 12.7 16.5 19.1 22.9	393 869 1016 1900 2671 3638	317 290 275 235 193 152	0.89 0.89 1.2 1.2 3.5 3.5

Nominal Size	Min. ID	Max. O.D.	Min. Wall Area	Min. C	Min. Mom. of Inertia	Min. Pipe Stiff.	Min. Wall Thick.
inch	inch	inch	inch <sup>2</sup> /ft.	inch	inch <sup>4</sup> /in.	psi	inch
12 15 18 24 30 36	11.8 14.8 17.7 23.6 29.5 35.5	14.7 18.0 21.5 28.7 36.4 42.5	1.50 1.91 2.34 3.14 3.92 4.50	0.35 0.45 0.50 0.65 0.75 0.90	0.024 0.053 0.062 0.116 0.163 0.222	46 42 40 34 28 22	0.035 0.035 0.045 0.050 0.125 0.125

The supplier shall certify that the resin used in the manufacture of pipe meets or exceeds the minimum cell classification requirements. Storage and handling shall be according to the manufacturer's recommendations except in no case shall the pipe be exposed to direct sunlight for more than 6 months. Acceptance testing of this pipe shall be accomplished during the same construction season in which it is installed.



**1040.23 Polyethylene (PE) Profile Wall Pipe.** This pipe shall be according to ASTM F 894 with a minimum cell classification of PE 334433 C or PE 335434 C as defined in ASTM D 3350. The section properties shall be according to AASHTO's Section 18. This pipe will require the manufacturer's certification that the material meets AASHTO's Section 18 properties. The manufacturer shall also certify that the resin used in the manufacture of the pipe meets or exceeds the minimum cell classification requirements. Storage and handling shall be according to the manufacturer's recommendations except in no case shall the pipe be exposed to direct sunlight for more than 6 months. Acceptance testing of this pipe shall be accomplished during the same construction season in which is is installed.



**1040.24 Polyvinyl Chloride (PVC) Profile Wall Pipe--794.** This pipe shall be according to ASTM F 794 with a minimum cell classification of 12454 C as defined in ASTM D 1784 and have a minimum pipe stiffness of 317 kPa (46 lbs./inch/inch). Acceptance testing of PVC Pipe and fittings shall be accomplished during the same construction season in which is is installed. The section properties shall be according to AASHTO's Section 18 properties. This pipe will require the manufacturer's certification that the material meets AASHTO's Section 18 properties.



1040.25 Polyvinyl Chloride (PVC) Profile Wall Pipe--304. This pipe shall be according to AASHTO M 304 with a minimum cell classification of 12454 C as defined in ASTM D 1784 and have a Acceptance testing of PVC pipe and fittings shall be accomplished during the same construction season in which it is installed. The section properties shall be according to AASHTO's Section 18. This pipe will require the manufacturer's certification that the material meets AASHTO's Section 18 properties.

# **SECTION 1041. BRICK**

- **1041.01** Building Brick (Made From Clay or Shale). Building brick, made from clay or shale, shall conform to the requirements of AASHTO M 114. The brick shall be of the grade designated as Grade SW.
- **1041.02** Concrete Building Brick. Concrete building brick shall conform to the requirements of ASTM C 55. The brick shall be of the grade designated as Grade S-II.

### SECTION 1042. CONCRETE MASONRY UNITS

**1042.01 Requirements.** Solid concrete masonry units shall conform to the requirements of ASTM C 139 and hollow load-bearing masonry units shall conform to the requirements of ASTM C 90 except that the aggregate shall conform to the requirements of Articles 1003.02 and 1004.02 with the exception of gradation. When the concrete has attained the required strengths, but not prior to 4 days after casting, the units may be loaded, shipped and used. Chert gravel may be used based on past in-service satisfactory performance in the environment in which the product is to be used.

# SECTION 1043. PRECAST REINFORCED CONCRETE MANHOLE SECTIONS

1043.01 Requirements. Precast reinforced concrete manhole sections shall conform to the requirements of AASHTO M 199M (M 199) except that the minimum wall thickness shall be 75 mm (3 inches), and the aggregate shall conform to the requirements of Articles 1003.02 and 1004.02 with the exception of gradation. When the concrete has attained the required strengths, but not prior to 4 days after casting, the units may be loaded, shipped and used. Chert gravel may be used based on past in-service satisfactory performance in the environment in which the product is to be used.

## **SECTION 1044. FLAP GATE**

- **1044.01 Cover.** The cover shall be cast iron, ASTM A 126, Class B, with necessary reinforcing ribs. It shall be fabricated with a lifting eye for manual operation, and with bosses to provide a pivot point connection with the links. Bosses shall be designed to place the hinge bolt in double shear when the gate is assembled. Pivot bosses shall be designed to limit the double hinge action, preventing the cover from rotating sufficiently to become wedged in the open position.
- **1044.02 Frame.** The one-piece cast iron frame shall be according to requirements of ASTM A 126, Class B.

The frame shall have a raised section around the perimeter of the waterway opening to provide the seating face. The raised section shall provide a seating plane diverging, top to bottom, from the plane of the mounting flange to assist in a positive closure of the cover.

The frame shall be flat back or spigot back as designated on the plans. The spigot back gates shall be designed for attaching to corrugated steel pipe.

1044.03 Seating Faces. The cast iron seating faces on the seat and the cover shall be machined to a plane with a minimum 1.6  $\mu$ m (63 microinch) finish.

The seating faces may be bronze conforming to the requirements of ASTM B 21M (B 21) - C48200 and shall be pneumatically impacted into dove - tailed grooves machined to 1.6  $\mu m$  (63 micro-inch) finish for maximum water tightness. Resilient seat, neoprene or Buna-N, when specified, shall be bonded in a groove machined in the frame to provide a wide seating surface for the seating face machined on the cover.

**1044.04 Top Pivot Connection.** The top connections to the hinge links or arms shall be with pivot lugs or some other system which has double bosses to place the top hinge bolts in double shear when they are assembled through the links or arms.

The connections shall be adjustable in the horizontal plane without removal of the cover from the gate links or arms. The adjustment shall allow the top pivots to be moved toward the gate seat for reduced sensitivity of the cover, or moved away from the gate seat, to provide opening with a minimum differential head.

**1044.05 Hinge Links or Arms.** The hinge arms connecting the cover and pivot lugs shall be high-tensile bronze, ASTM B 584-C86500, one-piece heavy duty cast iron, ASTM A 126, Class B, or high strength ductile iron, ASTM A 536, Gr. 65-45-12.

Each hinge link or arm shall have 2 pivot points, an adjustable lower pivot with limited rotation and a threaded upper hinge post to adjust flap gate sensitivity.

The bottom of the links or arms shall be provided with an adjusting screw to properly align seating faces on the cover with respect to the seat. The links or arms shall be designed to limit the double hinge action, preventing the cover from rotating sufficiently to become wedged in the open position.

Cast iron or ductile iron links or arms shall be provided with a commercial grade bronze bushing at each pivot point. The hinge pins designed in double shear shall be bronze, ASTM B 98M (B98) - C65500 or Type 304 stainless steel.

### 1044.06 Reserved.

- **1044.07 Fasteners.** All anchor bolts, screws, and nuts shall be galvanized steel, ASTM A 307 and ASTM A 164 of ample section to safely withstand the forces created by operation shown on the manufacturer's gate schedule.
- **1044.08 Painting.** All cast iron parts shall be grit-blast cleaned to base metal before painting. All ferrous parts of the flap gates shall be painted with a prime coat and shop coat. The paint shall be applied according to the manufacturer's standard practice.

All machined surfaces shall be coated with a water-resistant rust preventative coating.

# FILLERS, SEALERS AND WATERPROOFING ITEMS

### **SECTION 1050. POURED JOINT SEALERS**

- **1050.01 Cold-Poured Joint Sealer.** Cold-poured joint sealer, cold application type shall comply with the requirements of ASTM D 1850-74.
- **1050.02 Hot-Poured Joint Sealer.** Hot-poured joint sealer shall comply with the requirements of ASTM D 3405.

# SECTION 1051. PREFORMED EXPANSION JOINT FILLERS

- **1051.01 Methods of Sampling.** Two samples, each 300 mm (12 inches) in length and full width, will be taken for each 300 m (1000 ft.) or fraction thereof. Individual samples will be taken from separate pieces of preformed expansion joint filler selected at random.
- **1051.02 Methods of Testing.** In addition to Article 106.03, preformed expansion joint fillers will be tested as follows:

Extraction of Bitumen. The bitumen will be extracted by means of a Soxhlet extraction apparatus (large), equipped with a glass extraction shell having a round, perforated bottom. A small quantity of glass wool will be placed in the bottom of the extraction shell. Trichloroethylene shall be used as the extracting solvent. A sample weighing approximately 45 grams will then be cut into narrow strips and packed in the shell above the glass wool. The residue in the shell, after complete extraction of the bitumen, will be thoroughly dried at a temperature of 102 °C  $\pm$  3 °C (215 °F.  $\pm$  5 °F.), cooled, weighed, and the percent of bitumen determined by difference. Before extraction, the sample shall be dried for 3 hours in a constant temperature oven at 163 °C  $\pm$  3 °C (325 °F.  $\pm$  5 °F.).

**1051.03 Bituminous Preformed Joint Filler.** Bituminous preformed joint filler shall consist of bitumen, felt, and mineral.

The felt shall be roofing felt produced by the felting of vegetable and animal fibers. The felt shall be free from foreign substances, such as leather, rubber, straw, or wood.

The mineral shall consist of finely crushed slate, limestone, silica, sand, or similar mineral matter.

Roofing scrap may be used in the manufacture of joint filler provided the quality of felt and mineral are complied with.

The preformed joint filler shall not contain wood in ground form or otherwise, nor coarse fragments of any description, and the presence of straw or cornstalks used as a substitute for felt, or the presence of large particles of slate or other foreign matter will be deemed sufficient cause for rejection.

Bituminous preformed joint filler shall further comply with the requirements of AASHTO M 33 except that the percent of soluble material in the mastic portion will be based on an extraction made in trichloroethylene as specified in Article 1051.02.

- **1051.04 Preformed Fiber Joint Filler.** Preformed fiber joint filler shall comply with the requirements of AASHTO M 213 except that suitable binders other than bituminous will be permitted.
- 1051.05 Bituminous Preformed Inorganic Fiber Joint Filler. This material shall consist of a preformed strip made from inorganic fibers securely bound together and uniformly impregnated with a suitable bituminous binder. This strip shall be reinforced with a layer of felt paper on each side and shall conform to the requirements of AASHTO M 213, except that the minimum load to compress the material to 50 percent of its thickness before test is waived.
- **1051.06 Preformed Cork Joint Filler.** Preformed cork joint filler shall comply with the requirements of AASHTO M 153, Type II.
- **1051.07 Preformed Self-Expanding Cork Joint Filler.** Preformed self-expanding cork joint filler shall comply with the requirements of AASHTO M 153, Type III.
- **1051.08** Preformed Closed Cell Plastic Joint Filler. Preformed closed cell plastic joint filler shall consist of an extruded, low density, expanded polyethylene plastic foam. It shall have a closed cell structure that is chemically inert and has no food value that would attract or support plant or animal life. The plastic foam shall be odorless and non-toxic, remaining flexible over a wide range of temperatures, and be resistant to chemicals and solvents.

In addition to the above, the filler shall comply with the following requirements:

(a) Physical Properties and Test Methods.

Physical Properties and Methods of Tests	ASTM
Compression, kPa (psi) at 10% deflection, not less than 5 at 80% deflection, not greater than 125	D 1056
Moisture Vapor Permeability Permeability mm (inches), less than 0.4	E 96
Water Absorption % by volume, less than 0.5 *Use conditioning procedure 4.1.1 at 50° $\pm$ 3 °C.	C 272*
Density kg/m <sup>3</sup> (lbs./cu. ft.), not less than 38.4 (2.40)	D 1564

(b) Dimensions and Tolerances. Measurements for conformance to dimensional specifications must be made on a unit of stock which has been allowed to condition for one hour or longer at a temperature of 23 °C  $\pm$  6 °C (73 °F.  $\pm$  10 °F.). If the unit of stock is packaged or is a part of a pallet, it must be removed from the package or pallet and allowed to condition free from the insulating effect of the package or pallet.

- (1) The thickness shall have a tolerance of 13 mm (1/2 inch) and minus 0.
- (2) The width shall have a tolerance of 13 mm (1/2 inch) and minus 0.
- (3) The length shall be such that both ends can be squared and the joint filler cut to the required length.

## (c) Appearance

- Each piece of plank shall not contain more than 3% voids or hard spots.
- (2) The surface shall be smooth and reasonably free of dents or appendages. All packaged products shall be free of surface dirt and packaging damages.
- (3) The planks shall have no kinks or other deformities affecting straightness.

1051.09 Preformed Flexible Foam Expansion Joint Filler. Preformed Flexible Foam Expansion Joint Filler shall consist of a synthetic foam of isomeric polymers or other approved material in a small closed cell structure. It shall be chemically inert and have no food value that would attract or support plant or animal life. It shall be odorless and nontoxic, shall remain flexible over a wide range of temperatures, shall be compatible with hot poured joint sealer meeting the requirements of Article 1050.02 and shall have a melting point of 165 °C (330 °F.) minimum.

In addition to the above, the filler shall comply with the following requirements:

- (a) Physical Properties, ASTM D 545, 13-mm (1/2-inch) test specimen.
- (b) Dimension and Tolerance. Measurements shall be made on a unit of stock that has been conditioned at a temperature of 24 °C  $\pm$  4 °C (75 °F.  $\pm$  7 °F.) for a minimum of 24 hours.
  - (1) The thickness shall have a tolerance of 6 mm (1/4 inch) and minus 0.
  - (2) The width shall have a tolerance of  $\pm$  6 mm (1/4 inch).
  - (3) The length shall be equal to the lane width of the pavement and shall have a tolerance of  $\pm$  13 mm (1/2 inch).

### (c) Appearance

(1) Each piece of plank shall not contain more than 3% voids or hard

spots.

- (2) The surface shall be smooth and reasonably free of dents or appendages. All packaged products shall be free of surface dirt and packaging damages.
- (3) The planks shall have no kinks of other deformities affecting straightness.

### SECTION 1052, NEOPRENE EXPANSION JOINT

**1052.01 Description.** Neoprene Expansion Joint shall consist of molded anchor blocks of elastomeric and steel, field assembled over continuous lengths of elastomeric sealing membrane, with incidental accessories, sealants, and adhesives, as shown on the plans and as specified.

Shop drawings of the details and material of the neoprene expansion joint and incidental accessories, sealants, and adhesives shall be submitted to the Engineer for approval.

**1052.02 Materials.** The materials for the neoprene expansion joints and accessories shall comply with the following requirements:

(a) Elastomeric Materials. The elastomeric materials of the compounds for anchor blocks and sealing membrane shall be virgin polychloroprene (ASTM D, 2000 Table B) or ethylene propylene diene monomer (EPDM) having the following properties:

	ASTM STANDARD	REQUIREMENT
Durometer - Shore A Tensile Strength Ultimate Elongation Compression Set 22 Hours	D 2240 D 412 D 412	10.3 MPa (1500 psi) min.
@ 100 °C (212 °F.)(Method "B for Polychloroprene @ 70 °C (158 °F.) (Method "B	D 395	35% Max.
for EPDM Low Temperature Brittleness (Method "A") Non-brittle after 3 min.	D 2137	25% Max. Pass
@ 1 °C (34 °F.) Ozone Resistance Procedure		
"B" - D 518 100 PPHM Ozone for 70 Hours @ 38 °C (100 °F. Sample Under 20% Strain Bond During Vulcanization		No Cracks
(Method "B")	D 429	80% R

When test specimens are cut from the finished product, a 10% variation in "Physical Properties" will be allowed.

- (b) Steel reinforcement in anchor blocks. The steel reinforcement in anchor blocks shall be bonded to elastomer during vulcanization process and shall conform to ASTM A 570M (A 570) Grade D, AASHTO M 270, Grade 36, SAE 1020, or equal.
- (c) Adhesive and Sealant. The adhesive/sealant bedding compound for bonding the expansion joint seals to the concrete or steel seats shall be a polysulfide grout meeting the requirements of Federal Specification MMM-G-650B, Grade C with 50 percent filler material allowed.

The sealant for sealing between the ends of elastomeric anchor blocks, between edges of concrete block-out and anchor blocks, and for filling bolt hole cavities shall be a one or 2 part, non-sagging polysulfide or polyurethene black sealing compound meeting the requirements of Federal Specification TT-S-00230C, Type II.

Bedding and sealing compounds that do not meet the specifications shall not be used without prior approval of the Department. Other compounds submitted for approval will be evaluated on their ability to provide equivalent physical and functional properties.

- (d) Anchor Bolts, Threaded Rods, Washers and Nuts. Anchor bolts, threaded rods, washers and nuts shall either be stainless steel meeting the requirements of ASTM A 193M (A 193), Class 2 or shall conform to the requirements of AASHTO M 164M (M 164), zinc-coated according to Article 1006.08.
- (e) Automatically End Welded Threaded Studs, Washers, and Nuts. Automatically end welded threaded studs, washers, and nuts, shall be stainless steel meeting the requirements of ASTM A 193M (A 193). Welding and inspection of the threaded studs shall conform to Article 505.08(m).

**1052.03 Certification.** The Contractor shall furnish a certification by the manufacturer stating that the neoprene expansion joint and the accessory items meet the requirements approved by the Department. This will not constitute a waiver on the part of the Department of any requirements with respect to samples or samplings and the right is retained to perform any test deemed by the Department as necessary to qualify the materials.

# SECTION 1053. PREFORMED ELASTOMERIC COMPRESSION JOINT SEALS FOR CONCRETE

# 1053.01 Requirements.

- (a) Preformed elastomeric compression joint seals shall meet the requirements of AASHTO M 220 with the following modifications for the low compression seals for concrete pavement joints:
  - (1) The maximum loss in tensile strength after oven aging shall be 20 percent.
  - (2) The maximum loss in elongation at break after oven aging shall be 20 percent.
  - (3) When tested according to the procedures of ASTM D 575, Method A,

# Preformed Elastomeric Compression Joint Seals for Concrete

Art. 1053.01

the preformed elastomeric compression joint seal shall comply with the following requirements:

Nominal	Minimum Force Required	Maximum Force Required
Width	to Compress to 80% of	to Compress to 50% of
of Seal	Nominal Width of Seal	Actual Width of Seal
(mm)	(N/mm)	(N/mm)
20	0.5	2.1
30	0.7	2.1
50	0.7	2.1
90	0.7	2.1

Nominal	Minimum Force Required	Maximum Force Required
Width	to Compress to 80% of	to Compress to 50% of
of Seal	Nominal Width of Seal	Actual Width of Seal
(inches)	(Pounds/Inch)	(Pounds/Inch)
13/16 1 1/4 2 3 1/2	3 4 4 4	12 12 12 12 12

- (b) The lubricant-adhesive used with the preformed elastomeric joint seals shall meet the requirements of AASHTO M 220 with the following additional requirements:
  - (1) Average net weight per liter (gallon) 0.94 kg (7.84 lbs.)  $\pm$  5%
  - (2) Solids content, by mass, according to ASTM D 1084:  $25\% \pm 3\%$
  - (3) Film strength, minimum tensile strength, according to ASTM D 412: 15.8 MPa (2300 psi)
  - (4) Minimum elongation at breaking, according to ASTM D 412: 750%
  - (5) The lubricant-adhesive shall be accompanied by the manufacturer's certification of conformance with this Specification.
  - (6) Any lubricant-adhesive not used within 9 months of manufacture will be rejected.

### **SECTION 1054. NONMETALLIC WATER SEALS**

**1054.01 Description.** Nonmetallic water seals shall be either thermoplastic or rubber.

All nonmetallic water seals shall be produced by a process that will provide a

dense, homogeneous material free from imperfections. The cross section of the water seal shall be such as to ensure anchorage into the concrete by means of enlarged ends and/or fins and shall be approved by the Engineer. Nonmetallic water seal shall be capable of effectively sealing the joints in concrete against the infiltration of moisture.

- **1054.02 Polyvinyl Chloride (PVC) Water Seal.** The water seal shall be extruded from a specially compounded thermoplastic material consisting of a basic resin of polyvinyl chloride with additional resins, plasticizers, stabilizers, or other ingredient materials needed to provide a satisfactory water seal. Samples taken from the finished water seals shall meet the following requirements:
  - (a) Tensile Strength. The tensile strength shall be not less than 10.3 MPa (1500 psi).
  - (b) Elongation. The elongation shall be not less than 300 percent.
  - (c) Cold Bend. Specimens 25 mm (1 inch) wide and approximately 150 mm (6 inches) long shall be cooled until the material is between -18 °C and -23 °C (0 °F. and 10 °F.), then immediately bent 180 degrees around a mandrel 6 mm (1/4 inch) in diameter. The specimens shall show no cracking.
  - (d) The material shall have a low water absorption, a high resistance to acids and alkalies, and little deterioration under accelerated aging tests.
- **1054.03 Rubber Water Seal.** The water seal shall consist of natural rubber or a high grade synthetic rubber polymer compounded to produce satisfactory physical properties and aging characteristics. Samples taken from the finished water seals shall meet the following requirements:
  - (a) Tensile Strength. The tensile strength shall be not less than 17.2 MPa (2500 psi).
  - (b) Elongation. The elongation shall be not less than 400 percent.
  - (c) Hardness. The Shore A Durometer hardness shall be 60 to 70.
  - (d) Absorption. The absorption of water by weight shall be not greater than 5 percent.
  - (e) Specific Gravity. The specific gravity shall be 1.15  $\pm$  0.05.
  - (f) Strength After Aging. The tensile strength after air accelerated aging test of 48 hours in oxygen at 70 °C (158 °F.) and 2.1 MPa (300 psi) shall be not less than 80 percent of the original tensile strength.
  - (g) Test Methods. Tests will be made according to the following methods:
    - (1) Tensile Strength ASTM D 412
    - (2) Elongation ASTM D 412
    - (3) Specific Gravity ASTM D 297
    - (4) Absorption ASTM D 570
    - (5) Hardness ASTM D 2240
  - (h) Test Samples. The nonmetallic water seal will be sampled on the job or

at the source of supply as determined by the Engineer. The Contractor shall furnish 450-mm (18-inch) samples representative of the material being furnished. At the option of the Engineer, the manufacturer of the water seal may be required to submit a statement that the material furnished conforms to these requirements.

## SECTION 1055. MASTIC JOINT SEALER FOR PIPE

**1055.01 Requirements.** Cold-applied bituminous sealer for culvert and sewer pipe joints shall be a bituminous material of such consistency that it can be applied to the joints with a trowel when the temperature of the air is between -7 °C and 38 °C (20 °F. and 100 °F.), or it shall be a preformed bituminous material that can be applied to the joints by hand. The bituminous material shall adhere to the concrete or clay pipe so as to make a watertight seal and shall not flow, crack, or become brittle when exposed to the atmosphere.

Trowelable mastic joint sealer for pipe shall meet the following specific requirements:

Penetration 25 °C (77 °F.), 150 g., 5 sec., with cone	175-300
Loss on Heating, 163 °C (325 °F.), 5 hr., 50 g, percent	20 max.
Inorganic content [complete burn,	
645 °C to 760 °C (1200 to 1400 °F.)], percent	15-40
Flow at 60 °C (140 °F.), centimeters	
Pliable at -17 °C (0 °F.)	Yes

Trowelable mastic joint sealer for pipe shall be delivered to the project in suitable containers for handling and shall be sealed or otherwise protected from contamination. The container shall show the brand name, net volume or weight and the requirements for application.

# SECTION 1056. PREFORMED FLEXIBLE GASKETS AND MASTIC JOINT SEALER FOR SEWER AND CULVERT PIPE

**1056.01** Requirements. Preformed flexible gaskets and mastic joint sealer to be used for laying sewer and culvert pipe shall conform to the requirements of AASHTO M 198.

## **SECTION 1057. EXTERNAL SEALING BAND**

**1057.01 Requirements.** External sealing band, mastic, and film shall conform to the requirements of ASTM C 877M (C 877).

### **SECTION 1058. CONCRETE JOINT SEALER**

**1058.01** Requirements. The sealing compound shall be a liquid polymer type compound produced by mechanically mixing on the jobsite, according to manufacturer's recommendations, a liquid base polymer with a suitable curing component to form a homogeneous, liquid mixture suitable for filling and adhering to joints by pouring.

The polymer compounds shall be of a consistency that will permit their use at all temperatures above 10 °C (50 °F.) and shall be capable of completely filling the joint without formation of air holes or discontinuities.

Curing of the polymer compounds shall be by chemical reaction of the 2 components and not by evaporation of solvent or fluxing of harder particles. The sealant shall cure track and tack-free to traffic within 5-6 hours at 21 °C (70 °F.) and rising.

The materials forming the sealing compound shall comply with the following requirements:

Penetration, 25 °C (77 °F.), 150 gms., 5 sec., with cone
Bond Extension Test, -29 °C (-20 °F.), 3 cycles

Dry concrete block
Wet concrete block
Pass\*
Flow at 93 °C (200 °F.)
Resilience Test - Recovery
Air-cured
Oven-aged
Pass\*
70 plus percent
70 plus percent

\* None of the specimens shall develop any crack, separation, or other opening in the sealing compound or between the sealing compound and concrete block

The backer rod shall be rod stock of polychloroprene, rubber or other approved material of the size designated. The rod material when tested for 50 percent compression at 25 °C (77 °F.), according to ASTM D 1056, shall have a recovery of not less than 90 percent.

The joint materials shall be furnished by the manufacturer in containers of a type, size and kind commonly used for the purpose and so constructed as to insure acceptance and safe delivery by carriers. The shipping containers for the components of the sealing compound shall be clearly marked by the manufacturer with the name of material, name of manufacturer, brand name, weight, batch number, and recommended proportioning and handling procedures.

- **1058.02 Certification.** Prior to approval and use of the materials, the Contractor shall submit a notarized certification by the formulator and manufacturer of these materials stating that they meet these requirements. The furnishing of the certification, however, does not preclude the requesting of samples and testing by the Engineer as specified prior to acceptance of the materials.
- **1058.03 Testing.** The Engineer may require that the materials be tested prior to acceptance or the tests may be waived. When required, the tests shall be performed according to ASTM D 1191 except as herein modified. If so specified or if permissible by the manufacturer's recommendation, text specimens may be prepared by hand mixing in the designated proportions. If so specified by the manufacturer, the laboratory specimens shall be mixed by a laboratory size proportioning and mixing unit furnished by the manufacturer. The mixing and proportions shall be as recommended by the manufacturer.

All test specimens shall be conditioned or cured in air for 24 hours plus/minus 1 hour at a temperature of 24 °C  $\pm$  3 °C (75 °F.  $\pm$  7 °F.).

(a) Penetration. A 177 mL (6 oz.) seamless ointment-can shall be overfilled with the compound, the excess overfill struck off with a spatula or similar tool, and set aside to cure. Care should be taken to avoid entrapment of air. Five penetration readings shall be taken at a distance of not less than 13 mm (1/2 inch) from the edge of the can. The results of the penetrations shall be recorded as the average of the 5 readings.

- (b) Bond. The test shall be run at -29 °C  $\pm$  2 °C (-20 °F.  $\pm$  4 °F.) for 3 cycles. The test with wet blocks shall be made with blocks that have been immersed in water for a minimum of 24 hours, wiped free of water with a clean dry cloth and immediately assembled and filled.
- (c) Flow at 93 °C (200 °F.). The specimens shall be trimmed immediately after filing. The test shall be made at 93 °C ± 1 °C (200 °F. ± 2 °F.).
- (d) Resilience. A specimen shall be prepared as described above for the penetration test. Following the 24 hour air cure at 24 °C (75 °F.), it shall be maintained in air at a temperature of 25 °C  $\pm$  1 °C (77 °F.  $\pm$  2 °F.) for 1 hour. It shall then be placed in position in a penetrometer, ASTM D 5, except that a steel ball having a diameter of 17.1 mm  $\pm$  127  $\mu$ m (0.675 inch  $\pm$  0.005 inch) attached to a shaft of 5.52 mm (0.2175 inch) diameter and 49 mm (1.9375 inch) long with a suitable extension for inserting in the penetrometer, shall be substituted for the needle. The total mass (weight) of the moving plunger shall be 75 grams.

The ball shall be placed in contact with the surface of the specimen in air at 25 °C  $\pm$  1 °C (77 °F.  $\pm$  2 °F.) and the indicating dial shall be set at zero. The ball shall be loaded manually to cause it to penetrate the specimen to a dial reading of 100 at approximately a uniform rate in 10 seconds. The ball shall be locked in this position and held for 5 seconds, during which time the indicating dial shall be reset to zero. The locking mechanism shall then be released. At the end of 20 seconds, the indicating dial shall be read. Resilience of the original sample, expressed as a percentage, shall be reported as 100 minus the dial reading.

The specimen shall be placed in an air circulated oven at 70 °C  $\pm$  1 °C (158 °F.  $\pm$  2 °F.) for 24 hours. It shall then be removed and held at room temperature for one hour. It shall be maintained in air at a temperature of 25 °C  $\pm$  1 °C (77 °F.  $\pm$  2 °F.), for 1 hour and then tested for resilience as above described. The result shall be reported as resilience of the oven-aged sample.

## **SECTION 1059. ELASTIC JOINT SEALER**

**1059.01** Requirements. The joint sealer shall be composed of a mixture of materials that will form a resilient and adhesive compound capable of effectively sealing joints and cracks in bituminous pavements against the infiltration of moisture and foreign material throughout repeated cycles of expansion, contraction, and impact, and that will not flow from the joint or be picked up by vehicle tires at summer temperatures. The joint sealer shall be free of all foreign material and shall be capable of being brought to a uniform, smooth pouring consistency suitable for completely filling the joints without inclusion of large airholes or discontinuities and without damage to the material.

The joint sealer shall be of the hot-poured elastic type complying with the requirements of ASTM D 3405 except a certification from the manufacturer or supplier of the sealer will be required, certifying that the sealer is compatible with and capable of adhering to bituminous concrete.

### **SECTION 1060. WATERPROOFING MATERIALS**

- **1060.01 Description.** Waterproofing materials shall include asphalt primer, waterproofing asphalt, waterproofing asphalt emulsion, and butyl rubber membrane. All waterproofing materials used in a given construction shall be uniform in character, appearance, and consistency.
- **1060.02** Sources of Supply. All sources of supply shall be approved by the Department.
- **1060.03 Measurement of Volume.** Measurement of volume of asphalt primer, waterproofing asphalt and waterproofing asphalt emulsion will be based on the volume of the material at 15 °C (60 °F.). Volumes measured at higher or lower temperatures will be corrected to the volume of 15 °C (60 °F.), using the Standard ASTM-IP Petroleum Measurement Tables, ASTM D 1250.
- **1060.04 Delivery.** When waterproofing materials are not sampled at the source by a representative of the Department, they shall be delivered far enough in advance of their use on the work to permit the necessary tests to be made. Waterproofing materials shall be delivered in suitable containers or packages, plainly labeled to show the kind of material, the name of the manufacturer, and the lot or batch number. Each shipment shall be kept separate until the material has been accepted.
- **1060.05 Methods of Sampling.** In addition to the requirements of Article 106.03 the waterproofing materials will be sampled in samples of butyl rubber membrane shall be 900 mm (3 ft.) in length and full width of sheet.
- **1060.06 Asphalt Primer for Waterproofing.** Asphalt primer for waterproofing shall be Rapid Curing Liquid Asphalt RC-70 as specified in Article 1009.08 and shall be used prior to the application of waterproofing asphalts: AWP-Type I and AWP-Type II.
- **1060.07 Asphalt for Waterproofing: AWP.** Asphalt for waterproofing AWP shall be either Type I or Type II and shall conform to the requirements of AASHTO M 115.
  - Type I. For use in waterproofing below ground level. The asphalt shall be free from water and shall not foam when heated to a temperature of 177 °C (350 °F.).
- Type II. For use in waterproofing above ground level and for use in the construction of asphalt plank bridge floors. The asphalt shall be free of water and shall not foam when heated to a temperature of 204 °C (400 °F.).
- **1060.08 Asphalt Emulsion for Waterproofing.** Asphalt emulsion for waterproofing shall be an anionic type emulsion of asphalt in water with an asphalt content of 60 to 65 percent and a Saybolt Fural viscosity at 25 °C (77 °F.) of 20 to 80 seconds when tested according to AASHTO T 59. The asphalt residue recovered from distillation according to AASHTO T 59 shall conform to the requirements of AASHTO M 115, Type I, for asphalts for waterproofing with the exception; the ring and ball softening point shall be 65-88 °C (150-190 °F.). In addition, the material shall meet the moisture retention requirements specified in Article 1022.01(f) and shall pass the following tests for resistance to water action, freeze recovery, and rain resistance:

- (a) Resistance to Water Action. When tested according to ASTM D 466, no lifting of the film or darkening of the water will be permitted.
- (b) Freeze Recovery. Freeze recovery shall be tested in the following manner. Soak an unglazed ceramic tile, as used in ASTM D 466, in distilled water for 10 minutes. Then place the tile in a freezer until the ice crystals form on the surface, at which time the tile is removed from the freezer and immediately coated with emulsion at room temperature as per ASTM-D-466. The coated tile is then replaced in the freezer. After 5 hours, the tile is removed from the freezer and dried as per ASTM D 466. After drying, the tile is tested as per ASTM D 466. No lifting of the film or darkening of the water will be permitted.
- (c) Rain Resistance. Rain resistance shall be tested as follows. Dampen 100 grams of dry 6 mm to 9 mm (1/4" to 3/8") stone chips with 1 gram of water. Add 5 grams of emulsion to the damp chips and mix for 2 minutes. When mixing is completed, place the coated chips on a screen and immerse them in a container of water at room temperature allowing them to soak 1 minute without movement. After soaking, remove from the water and examine for loss of coating. No loss of coating will be permitted.

**1060.09 Butyl Rubber Membrane.** Butyl rubber membrane shall be 3-mm (1/8-inch) thick. Rubber membrane shall be a compound butyl elastomer of the IIR Family (Isobutylene-Isoprene rubber) conforming to the following requirements:

(a) Butyl Membrane.

Color	Black			
Specific gravity	$1.20 \pm 0.03$	ASTM D 297		
Tensile strength	8300 kPa (1200 psi) (min)	ASTM D 412		
Modulus at 300% elongation	4100 kPa (600 psi) (min)	ASTM D 412		
Elongation	300% (min)	ASTM D 412		
Tear resistance, die B	1034 kPa (150 psi) (min)	ASTM C 624		
Hardness, shore A	55 ± 5 with 5-sec interval			
	before reading	ASTM D 2240		
Ozone resistance,				
70 hr. at 38 °C (100 °F.)				
in 50 PPHM Ozone;				
20% elongation		no cracks		
Heat Aging, 7 days at 116 °C (240 °F.)70% of original properties				
Maximum vol. swell				
(Triscresyl Phosphate				
Immersion) 72 hr. at 100 °C (212 °F.)10				
Operating temperature range40 °C to 135 °C (-40 °F. to 275 °F.)				
Water absorption, volume cha	ange	less than 1%		
Adhesive Adhesive for secu	iring hutyl rubber membrane a	and the protective		
Adhesive Adhesive for secu	iring hutyl rubber membrane a	and the protective		

- (b) Adhesive. Adhesive for securing butyl rubber membrane and the protective cover shall be compatible to the membrane waterproofing and with the materials to which it is bonded. It shall remain workable to its brittle point [-40 °C (-40 °F.)].
- (c) Rubber Cement. Rubber Cement for splicing rubber membrane shall be a self-vulcanizing butyl rubber compound conforming to the following requirements:

Viscosity No. 3 Zahn Cup [25 °C (77 °F.)] 100 to 150 sec. Total Solids 30% (min.)

(d) Butyl Gum Tape. Butyl gum tape for splicing butyl membrane shall be black, unvulcanized butyl rubber with an 200  $\mu$ m (8-mil) polyethylene film backing. The tape shall be 0.8 mm (30 mils)  $\pm$  100  $\mu$ m ( $\pm$  4) thick, including the backing.



## SECTION 1061. WATERPROOFING MEMBRANE SYSTEM

- **1061.01 Description.** The waterproofing membrane system materials shall consist of a penetrating primer, coal tar pitch emulsion, fiber glass, slurry seal top coat and a sand asphalt seal protection layer.
- **1061.02 Penetrating Primer.** The primer shall be a cationic, highly penetrating bituminous solution that is compatible with the coal tar pitch emulsion and suitable for use on portland cement concrete surfaces. Asphaltic primers will not be permitted.
- **1061.03 Coal Tar Pitch Emulsion.** The coal tar pitch emulsion shall be compounded of heavy closed ring hydrocarbons dispersed in water by means of a combination of irreversible collodial clays.
  - (a) Sampling and Testing. Prior to approval and use of the material for coal tar pitch emulsion and penetrating primer, the Contractor shall submit a certification by the manufacturer of this material, stating that it meets these requirements. This shall not constitute a waiver on the part of the Department of any requirements with respect to samples and samplings, and the right is retained to perform any or all of the tests specified.
  - (b) Ingredient Materials. The coal tar pitch used in production of this material shall have a specific gravity of 25 °C/25 °C (77 °F./77 °F.) of 1.20 to 1.27. By continuous hot extraction with benzol, after digesting in toluol, the insolubles ordinarily described as free carbon shall not be less than 12 percent. A cylinder of the pitch 13 mm (1/2 inch) in diameter and 150 mm (6 inches) long which has been immersed in melting ice for at least 30 minutes shall withstand being bent double without developing cracks at the point of greatest deflection; a duplicate cylinder which has been immersed in melting ice for at least an hour shall withstand twisting for two complete turns of 360° each without showing cracks or fractures. The pitch shall not be fluxed back with light oils, solvents, or any other adulterants before or during the emulsification process. Since these characteristics are not subject to test after emulsification, they are to be certified by the manufacturer.

The emulsion shall contain no sulphite pitches, asphalt, bentonite, coal dust, soluble soaps, or sulphonic acid and shall have sufficient thixotropic property so that at temperatures of 21 °C (70 °F.) it may be temporarily reduced with agitation, to applied liquidity without addition of adulterants, to provide easy workability with brush or squeegee, and then reset in place.

- (c) Properties.
  - (1) Specific Gravity. A sample of the emulsion shall show a specific gravity at 25 °C/25 °C (77 °F./77 °F.) of between 1.22 and 1.29.
  - (2) pH. pH of the emulsion shall be 7.0 to 9.0 at 25 °C (77 °F.).
  - (3) Nonvolatile Matter. A sample of the emulsion when treated in an oven according to ASTM D 2939, shall show a minimum nonvolatile matter

- of 52 percent. This residue, when heated from room temperature to 270 °C (518 °F.) in an oven within 30 minutes time, shall show a loss of not more than 10 percent by mass (weight).
- (4) Ash Content. A sample of the residue from the determination of nonvolatile matter according to ASTM D 2939 shall show an ash content of 30 percent to 40 percent.
- (5) Resistance to Freezing.\* A sample of the emulsion fortified with antifreeze shall be tested according to ASTM D 244. After exposure to a temperature of -18 °C (0 °F.) shall return to a homogeneous consistency with stirring.
  - \*NOTE: The emulsion shall be fortified with antifreeze where climatic conditions surrounding the material in transit or storage are such to make resistance to freezing necessary.
- (6) Consistency. The emulsion when spread to a thin film with a spatula on a sheet of standard 8.16 kg (18 lbs.) paper shall flow with a uniformly smooth nongranular consistency free from coarse particles which are either apparent or which cause film voids as the material is drawn out to a smear.
- (7) Flammability. The material shall be nonflammable when exposed to flame.
- (8) Drying Time. A test panel prepared according to ASTM D 2939, and exposed at a temperature of 25 °C (77 °F.) and 50 percent relative humidity in activated air shall set for touch within 3 hours and set within 4 hours.
- (d) Cured Film Performance.
  - (1) Resistance to Motor Oil, Gasoline, and Distilled Water. A 2 coat film of the emulsion with a minimum cured thickness of 1.5 mm (1/16") shall be prepared on a 150 x 150 mm (6 x 6") tile according to the Methods of Testing Films Deposited from Bituminous Emulsions, ASTM D 466. The cured film shall be tested according to ASTM D 466, using the above specified test liquids, except the test period shall be 48 hours. At the end of the test period, the test liquid shall be poured off and the film inside the ring impressions shall show no sign of film penetration nor loss of adhesion.
  - (2) Heat Test. A 1.5 mm (1/16") cured film of the emulsion shall be prepared and tested according to ASTM D 2939. At the end of the test period, none of the film shall have slipped below the reference line.
  - (3) Flexibility. A 1.5 mm (1/16") cured film of the emulsion shall be tested for flexibility according to ASTM D 2939. Immediately after bending, the film shall show no signs of cracking, flaking, or loss of adhesion.
  - (4) Resistance to Impact. A 1.5 mm (1/16") cured film of the emulsion shall be prepared on a 75 x 150 x 1.5 mm (3 x 6 x 1/16") cold rolled and pickled steel plate for exposure in an accelerated weathering machine conforming to ASTM G 23, Type E or EH as listed in ASTM D 529. The film shall be cured with activated air at 25 °C (77 °F.) at 50 percent relative humidity for 96 hours, then introduced into the weathering machine, and exposed to cycle B as described in

the Recommended Practice for Accelerated Weathering Test of Bituminous Materials, ASTM D 529 for 120 hours. The test panel shall then be placed over a 60-mm (2 3/8-inch) hole in a wood block and a 0.91-kg (2-lb.) steel ball shall be dropped from a level of 2.44 m (8 ft.) directly above the block. The impact of the ball on the specimen panel over the hole shall not spall the film to reveal the metal.

**1061.04 Fiber Glass Fabric.** The fiber glass fabric shall conform to the requirements of the "Woven Glass Fabrics Treated for Use in Waterproofing and Roofing", ASTM D 1668, Type II or III, except that selvage edges will not be required, and the heat loss test shall not apply to coal tar pitch treated fabric.

**1061.05** Aggregate for Slurry Seal Top Coat. The aggregate shall meet the requirements of Article 1003.01 be clean, dry, hard, and shall contain a minimum of dust. It shall be graded as follows:

Sieve Size	Passing Percent
2.36 mm (No. 8)	100
2.00 mm (No. 10)	90 - 100
1.18 mm (No. 16)	10 - 75
600 μm (No. 30)	0 - 10

**1061.06 Protection Layer.** The protection layer shall be a hot-mix-sand asphalt seal composed of the following materials:



Bituminous Material. The bituminous material shall be asphalt cement Grade AC 10 or AC 20 meeting the applicable requirements of Section 709.

Fine Aggregate. The fine aggregate shall consist of sand, stone sand, or slag sand, Class B Quality or better, gradation FA 20, meeting the applicable requirements of Article 1003.01, except that no Type A or Type B sands will be allowed.

### SECTION 1062. REFLECTIVE CRACK CONTROL SYSTEM

**1062.01** Reflective Crack Control System A. The reinforcing fabric shall be a nonwoven polypropylene or other approved plastic fabric having the following properties:

Weight (ASTM D 3776) g/m <sup>2</sup> (oz./sq. yd.), min.	135 (4.0)
Grab Tensile Strength (ASTM D 4632) N (lbs.), min.	400 (90.0)
Grab Elongation at Break (ASTM D 4632) %, min-max.	40-100
Asphalt Retention L/m <sup>2</sup> (gals./sq. yd.), min.	0.9 (0.20)



The asphalt binder shall be AC 10 or AC 20 meeting the requirements of Article 1009.05.

**1062.02 Reflective Crack Control System B.** Waterproofing membrane interlayer shall incorporate a high strength fabric embedded in a layer of self-adhesive suitably plasticized bitumen with the following properties:

<u>Property</u>	<u>Value</u>	Test Method
Thickness Permeance-Perms	1.65 mm (0.065 inch), min. 1.0 (0.10) max	ASTM E 96 Procedure B
Tensile Strength	8.7 N/mm (50 lb./in.), min.	ASTM D 882 (modified for 25 mm (1") opening)
Puncture Resistance (fabric)	90 kg (200 lbs.), min.	ASTM E 154
Pliability -12.7 mm (-1/2 inch)-mandrel	No cracks in fabric or plasticized bitumen	ASTM D 146

# 1062.03 Reflective Crack Control System C.



- (a) Asphalt. The grade of asphalt cement for the asphalt-rubber mixture shall comply with the applicable requirements of Article 1009.05 and shall be either AC 5 or AC 10.
- (b) Emulsified asphalt for tack coat shall be SS-1, SS-1h, CSS-1h and shall comply with the requirements of Article 1009.07.
- (c) Vulcanized Rubber. The granulated crumb rubber shall be 100 percent vulcanized and meet the following gradation requirements:

<u>Sieve Size</u>	Percent Passing
2.36 mm (No. 8)	100
2.00 mm (No. 10)	98-100
600 μm (No. 30)	0- 10
425 μm (No. 40)	0- 4

The specific gravity of the material shall be 1.15  $\pm$  0.02 and shall be free from fabric, wire, or other contaminated materials, except that up to 4 percent calcium carbonate may be included to prevent the rubber particles from sticking together.

Vulcanized rubber will be accepted by certification from the rubber supplier.

- (d) Diluent. The diluent shall be a solvent with an initial boiling point (IBP) of +350 when tested according to ASTM D 86.
- (e) Crumb Rubber Blend. The rubber shall be a blend of 40% powdered devulcanized rubber and 60% ground vulcanized rubber scrap specially selected to have a high natural rubber content. The blend shall meet the following specifications:

<u>Sieve Analysis</u>	(ASTM D 1151)
Sieve Size	% Passing
2.00 mm (No. 10)	100
600 μm (No. 30)	60-80
300 μm (No. 50)	35-70
150 μm (No. 100)	10-25

The natural rubber content shall be a minimum of 30 percent by mass

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(weight), ASTM D 297M (D 297). The devulcanized rubber content of the blend shall be 40 percent by mass (weight) and shall be determined by a mill test as follows:

When 40-50 grams of rubber retained on the 600  $\mu m$  (30 mesh) sieve are added to the tight 150-mm (6-inch) rubber mill, the material should bond on the mill roll in one pass, and should usually be retained on the mill roll. This will indicate the presence of a suitable quantity of devulcanized rubber. The crumb rubber blend will be accepted by certification from the rubber supplier.

- (f) Extender Oil. Extender oil shall be compatible with all materials used and be a high flash, high viscosity resinous aromatic rubber extender oil.
- (g) Cover Aggregate. Aggregates for cover material shall meet the requirements of Article 1004.03 for Class A bituminous courses except only CA 14 or CA 15 will be allowed.

### SECTION 1063. FIBERGLASS FABRIC REPAIR SYSTEM

**1063.01 Requirements.** The Fiberglass Fabric Repair System shall consist of two components, fiberglass and bituminous adhesive.

The fiberglass fabric shall consist of a heavyweight high strength woven fiberglass roving conforming to the following physical properties:

Strip tensile strength,
 ASTM D 579 Modified
25-mm (1-inch) cut strip test, Procedure 2
Strain rate of 15 mm/min. (0.5 inch/min.)
in a CRE testing machine,
75-mm (3-inch) gage length, test both
warp and fill directions.

140 N/mm (800 lbs./inch) min.

Mass (Weight)

745 g/m<sup>2</sup> (22 oz./sq. yd.), min.

The Bituminous Adhesive shall consist of an asphaltic polymer that has high adhesion and low tack and is compatible with the fiberglass fabric, and shall conform to the following physical properties:

Thermal Stability, ASTM D 3407 Prolonged Heating Method, 6 hrs. @ 205 °C (400 °F.) and the retested sample shall conform to the requirements above and the following:

# Art. 1063.01 Fiberglass Fabric Repair System

Low Temperature Flexibility,
ASTM C 711 Mod. ...... -23 °C (-10 °F.) (max.)
[25 mm (1-inch) diameter mandrel]

The Fiberglass Fabric Repair System shall consist of the fabric coated on both sides with bituminous adhesive and shall conform to the following physical properties:

25 mm (1-inch) cut strip test, Procedure 2 Strain rate of 15mm/min. (0.5 inch/min.) in a CRE Testing machine, 75 mm (3-inch) gage length, test both warp and fill directions.

### OTHER ITEMS

## **SECTION 1080. FABRIC MATERIALS**

**1080.01 Fabric Envelope for Pipe Underdrains.** The fabric envelope for encasing perforated corrugated polyethylene (PE) tubing may be either a knitted, woven, or nonwoven fabric.

# (a) Fabric Materials

- (1) Knitted Fabric. Knitted fabric envelope shall be an approved continuous one-piece knitted polyester material that fits over the 100 mm (4-inch) PE tubing like a sleeve. It shall be knitted of continuous 150-denier polyester yarn and shall be free from any chemical treatment or coating that might significantly reduce porosity and permeability.
- (2) Woven or Nonwoven Fabric. The filaments for woven or nonwoven fabric shall be polypropylene, polyester, or polyethylene. The filaments must be dimensionally stable (i.e., filaments must maintain their relative position with respect to each other) and resistant to delamination. The filaments must be free from any chemical treatment or coating that might significantly reduce porosity and permeability. Nonwoven fabric shall be needle punched.
- (3) Physical Properties. The physical properties for both knitted and woven or nonwoven fabric shall conform to the following:

PHYSICAL PROPERTIES								
	Knitted							
Min. Weight (g/m <sup>2</sup> )		ASTM D 3887 ASTM D 3887	120 ASTM D 3776					
Min. Wet Grab Tensile Strength (N)	225	ASTM D 4632	450 <sup>1/</sup> ASTM D 4632					
Grab Elongation @ Break	(%)		20 min. <sup>1/</sup> ASTM D 4632					
Equivalent Opening Size (EOS No.)	600 μm min	<b>2</b> corps of Engrs. CW-02215	600 $\mu m$ nonwoven <sup>2/</sup> 300 $\mu m$ min. woven <sup>2/</sup>					
Burst Strength (kPa)	690 min. <sup>2/</sup>	ASTM D 3887						

PHYSICAL PROPERTIES (ENGLISH)							
	ł	Knitted	Woven or Nonwoven				
Min. Weight (oz./sq. yd.)		ASTM D 3887 ASTM D 3887	3.5 ASTM D 3776				
Min. Wet Grab Tensile Strength (lbs.)	50	ASTM D 4632	100 <sup>1/</sup> ASTM D 4632				
Grab Elongation @ Break	c (%)		20 min. <sup>1/</sup> ASTM D 4632				
Equivalent Opening Size (EOS No.)	30 min. <sup>2/</sup>	Corps of Engrs. CW-02215	30 min. nonwoven <sup>2/</sup> 50 min. woven <sup>2/</sup>				
Burst Strength (PSI)	100 min. <sup>2/</sup>	ASTM D 3887					

- 1/ For woven fabric, test results shall be referenced to orientation with warp or fill, whichever the case may be.
- 2/ Manufacturer's certification to meet test requirements.
  - (b) Handling and Storage. The knitted fabric envelope shall be applied to the 100-mm (4-inch) PE tubing in the shop so as to maintain a uniform applied weight. Woven and nonwoven fabric or tubing with knitted fabric envelope shall be delivered to the jobsite in such manner as to facilitate handling and incorporation into the work without damage. Fabric envelope materials shall be stored in UV-resistant bags until just prior to installation. In no case shall the fabric be stored or exposed to direct sunlight that might significantly diminish its strength or toughness. Torn or punctured fabric envelope shall not be used.

**1080.02 Geotextile Fabric.** Fabric for Ground Stabilization and Silt Filter Fence shall consist of woven or nonwoven filaments of polypropylene, polyester, or polyethylene. Nonwoven fabric may be needle punched, heat-bonded, resin-bonded, or combination thereof. The filaments in the Silt Filter Fence Fabric must be dimensionally stable (i.e., to each other), resistant to delamination, and must be free from any chemical treatment or coating that might significantly reduce porosity and permeability. Both fabrics shall be resistant to ultraviolet radiation. The fabrics shall comply with the following physical properties.

Ground Stabilization	Silt Filter Fence Fabric	
900 (min.) 1/	900 (min.) 1/	
12 (min.) 1/ 1720 (min.) 2/ 1720 (min.) 2/		
335 2/	-	
-	1 (min.)	
135 (min.)	135 (min.)	
- 5	600 μm (min.) (nonwoven) 2/ 300 μm (min.)(woven) 2/	
	900 (min.) 1/ 12 (min.) 1/ 1720 (min.) 2/ 335 2/ - 135 (min.)	

Physical Properties (English)	Ground Stabilization	Silt Filter Fence Fabric
Grab tensile strength (lbs) - ASTM D 4632	200 (min.) 1/	200 (min.) 1/
Grab elongation @ break (%) - ASTM D 4632	12 (min.) 1/	12 (min.) 1/
Burst strength (psi) - ASTM D 751	250 (min.) 2/	250 (min.) 2/
Trapezoidal tear strength (lbs) ASTM D 4533	75 2/	-
Width (ft.)	-	3.5 (min.)
Weight (oz/sq yd.) - ASTM D 3776	4.0 (min.)	4.0 (min.)
Equivalent opening size (EOS) Sieve No Corps of Engrs. CS-02215	-	30 (min.)(nonwoven) 2/ 50 (min.)(woven) 2/

- 1/ For woven fabric, test results shall be referenced to orientation with warp or weave, whichever the case may be. Both woven and nonwoven fabric shall be tested wet.
- 2/ Test results may be obtained by manufacturer's certification.

1080.03 Filter Fabric For Use With Riprap. The filter fabric material shall consist of nonwoven filaments formed from a plastic yarn of a long-chain synthetic polymer composed of at least 85 percent by weight of polyolefins, or polyesters, and shall contain stabilizers and/or inhibitors added to the base plastic to make the filaments resistant to deterioration due to ultraviolet and heat exposure. After forming, the fabric shall be processed so that the filaments retain their relative positions with

respect to each other. The fabric shall be free of defects or flaws which significantly affect its physical and/or filtering properties.

The filter fabric shall be formed in widths of not less than 2 m (6 ft.). Sheets of fabric may be sewn together with thread of a material meeting the chemical requirements given for the plastic yarn to form fabric widths as required. The sheets of filter fabric shall be sewn together at the point of manufacturer or another approved location.

The texture of the fabric shall be such that the bedding and riprap will remain in an equilibrium state and not slip or slide. The filter fabric shall be rot proof, mildew proof, insect resistant, have a high dimensional stability when set, have good soil filtration characteristics, have a high resistance to tear propagation in all directions, and meet the following minimum conditions and ASTM Tests for the gradation of riprap specified:

	Gradation 4 & 5	Gradation 6 & 7
Weight of Fabric (g/m²), ASTM D 3776 (Mod.) Burst Strength (kPa), ASTM D 3786 (Note 1) Trapezoidal Tear Strength (N), ASTM D 1117 (Note 2) Grab Tensile Strength (N), ASTM D 4632 (Note 2) Grab Tensile Elongation (%), ASTM D 4632 (Note 2)	200 1720 265 700 20	270 2070 335 900 20

ENGLISH UNITS	Gradation 4 & 5	Gradation 6 & 7
Weight of Fabric (oz/sq yd), ASTM D 3776 (Mod.) Burst Strength (psi), ASTM D 3786 (Note 1) Trapezoidal Tear Strength (lbs), ASTM D 1117 (Note 2) Grab Tensile Strength (lbs), ASTM D 4632 (Note 2) Grab Tensile Elongation (%), ASTM D 4632 (Note 2)	6.0 250 60 160 20	8.0 300 75 200 20

- Note 1. Manufacturer's certification of fabric to meet requirements.
- Note 2. Test sample shall be tested wet.

The vendor shall furnish certified test reports with each shipment of material attesting that the fabric meets the above requirements.

A sample of 4.0 m<sup>2</sup> (5 sq. yds.) of the fabric shall be furnished from each shipment for verification testing.

The fabric shall meet the requirements noted in the following and provide an AOS (apparent opening size) determined by the Engineer after an on-site investigation of the soil to be protected, based on the following criteria:

- (a) Piping Resistance. (soil retention) (Note 1)
  - (1) Soil with 50 percent or less particles by mass (weight) passing U.S. 75  $\mu$ m (No. 200) Sieve. AOS less than 0.6 mm [greater than 300  $\mu$ m (No. 30) Sieve] TF25 Method 6.

- (2) Soil with more than 50 percent particles by mass (weight) passing U.S. 75  $\mu m$  (No. 200) Sieve. AOS less than 0.3 mm [greater than 300  $\mu m$  (No. 50) Sieve] TF25 Method 6.
- (b) Permeability. (cm/sec)(Note 1). K of fabric greater than 10K of soil - ASTM D 4491.

Note 1. Certification from the manufacturer of fabric is required stating that the product meets the piping resistance and permeability requirements.

For 1080.04 Fabric Fabric Formed Concrete Revetment Fabric-forming material shall consist of specially woven, double layer, open-selvage fabric joined in mat configuration. The fabric shall consist of uncoated synthetic yarns with sufficient grab tensile strength and porosity to withstand the pressure of the grout injection pump without breaking the layers of fabric. Each fabric layer shall exhibit minimum grab tensile strength of 900 N (200 lbs.) in both warp and fill directions when tested according to ASTM D 4632, Grab Tests, Method 16, using a 100 x 200 mm (4 x 8") sample, 75-mm (3-inch) gage length, clamped in a 25 mm (1 inch) wide by 50 mm (2 inch) long grip, tested at a strain rate of 300 mm/minute (12 inch/minute) in a CRE testing machine. The average of 5 tests in each direction shall meet the minimum value given above. The fabric shall be tested wet.

Hydrostatic uplift pressure relief shall be provided by installing 40 mm (1 1/2 inch) diameter sewn filter points woven in such a manner as to permit passage of water through the filter points spaced approximately at 200-mm (8-inch) centers for the Filter Point style mat with average thickness of 90 mm (3.5 inches), and at 2.4 m (8 ft.) centers for the Uniform Cross Section style mat with average thickness of 100 mm (4 inches). All filter points shall be checked and cleaned for free passage of water through the filter points after the mat has been pumped and the cement grout has set. When uniform cross section style mat is specified, the Contractor shall have the option of substituting filter point style mat.

**1080.05 Geotechnical Fabric for French Drains.** Geotechnical fabric for french drains shall consist of woven or nonwoven filaments of polypropylene, polyester, or polyethylene. Nonwoven fabric may be needle punched, heat-bonded, resin-bonded or combinations thereof. The filaments must be dimensionally stable (i.e., filaments must maintain their relative position with respect to each other) and resistant to delamination. The filaments must be free from any chemical treatment or coating that might significantly reduce porosity and permeability.

(a) Physical Properties. The fabric shall comply with the following physical properties:

Weight g/m <sup>2</sup> (oz./sq. yd.)	120 (3.5) min.	ASTM D 3776
Grab tensile strength N (lbs.)	450 <sup>1/</sup> (100) min. <sup>1/</sup>	ASTM D 4632
Grab elongation @ break (%)	20 min. <sup>1/</sup>	ASTM D 4632
Equivalent opening size (EOS NO.) Nonwoven Woven	600 μm (30) min <sup>2/</sup> 300 μm (50) min. <sup>2/</sup>	CW-02215-77 Corps of Engineers

### Fabric Materials

- 1/ For woven fabric, test results shall be referenced to orientation with warp or fill, whichever the case may be. Both woven and nonwoven fabrics shall be tested wet.
- 2/ Manufacturer's certification of fabric to meet requirements.

### **SECTION 1081. MATERIALS FOR PLANTING**

**1081.01 Trees, Shrubs, Vines, and Seedlings.** Trees, shrubs, vines and seedlings shall conform to the standards adopted by the American Association of Nurserymen.

- (a) Quality of Plant Material.
  - (1) Plants shall be first class nursery grown representatives of their normal species and varieties. They shall have average or normal well developed branches, together with vigorous root systems. Plants shall be free from insects, diseases, sun scald, knots, stubs, or other objectionable disfigurements. Thin, weak plants will not be accepted.
  - (2) Trees shall be free of branches (undertrimmed) no higher from the ground line than 1/2 the total height of the tree; shall have single leaders, be well branched, and with reasonably straight stems. This requirement shall cover general species, but some varieties, which have other characteristics of growth, will be accepted.
  - (3) Plants shall be true to their name as specified. Substitution of plant material of equal quality, type, and size to that specified may be approved by the Engineer at no change in unit price if acceptable material of the variety specified is not available. Permission shall be given only after a written request and proposal for substitution is received from the Contractor 30 days prior to the proposed planting date.
  - (4) Wherever the word "specimen" is used, it shall denote trees which are symmetrical, exceptionally heavy, and full branched. When more than one is required, all shall be uniform in size and shape.
  - (5) The southernmost limits for the source of plant material shall be one sub-zone south of the site of the work. Plant Hardiness Zones shall be as designated in the current Miscellaneous Publication No. 814, Agricultural Research Service USDA. All Illinois counties located in sub-zone 5a shall be considered part of sub-zone 5b. All counties located in sub-zone 7a shall be considered part of sub-zone 6b.
- (b) Measurement for Size.
  - Root System. The root system of all plants shall be sufficient to ensure plant growth.
    - a. Bareroot Trees. All bareroot trees shall have a heavy fibrous root system that has been developed by proper cultural treatment, transplanting, and root pruning. The spread of the root system shall be 12 times greater than the trunk diameter plus an additional 150 mm (6 inches).
    - b. Bareroot Shrubs. All bareroot shrubs shall have a well-branched

fibrous root system, the minimum spread of which shall be as follows:

Height of Plant	Minimum Spread of Roots
450-600 mm (18-24")	250 mm (10")
600-900 mm (2-3')	275 mm (11")
900 mm-1.2 m (3-4')	350 mm (14")
1.2-1.5 m (4-5')	400 mm (16")
1.5-1.8 m (5-6')	450 mm (18")
1.8-2.4 m (6-8')	500 mm (20")

- (2) Container Grown Plants. Container grown plants shall be well rooted and established in the container in which they are growing. They shall have grown in the container for a sufficient length of time for the root system to hold the earth when taken from the container, but not long enough to become pot bound. The size of the containers shall be not less than 75 percent of the ball sizes for comparable balled and burlapped plant material. Containers shall be stable and not deteriorated to a degree which will cause breaking up of the root ball during the planting operation.
- (3) Balled and Burlapped Plants. Plants marked "B&B" are to be balled and burlapped, and shall be dug with a sufficient quantity of earth taken equally on all sides and bottoms of the plants to include the necessary roots to ensure growth. The thickness of depth of the balls shall be sufficient to include the depth of the roots according to species. The balls shall be prepared in a professional manner and firmly bound. A burlap and twine or rope shall readily decompose after planting.

With relation to the height and trunk diameter of the plants, the top diameter of the balls of earth must be equal to or greater than those given in the schedule of minimum sizes in Table I. It shall be understood that the ball sizes are the minimum which will be accepted for the corresponding height and trunk diameter of the plants. Where soil types, climatic conditions, or infrequent root pruning or transplanting in the nurseries have caused roots greater than 13 mm (1/2 inch) in thickness to extend beyond the above minimum ball diameter, the ball diameter must be increased so that no roots greater than 13 mm (1/2 inch) in thickness, except tap roots, are cut.

TABLE I									
TYPE 1 Spreading Conif. and Broadleaf Evergreens		Broad Conif. Colu and Broadleaf Co		TYF Colui Co Everg	mnar Shrubs nif. Small Ti		YPE 4 rubs and Stand all Trees Shar		dard ide
Spread (Meter)	Min. Diam. Ball (mm)	Height (Meter)	Min. Diam. Ball (mm)	Height (Meter)	Min. Diam. Ball (mm)	Height (Meter)	Min. Diam. Ball (mm)	Diam. (mm)	Min. Diam. Ball (m)
0.5-0.6 0.6-0.7 0.7-0.9 0.9-1.0 1.0-1.2 1.2-1.5 1.5-1.8 1.8-2.1 2.1-2.4 2.4-2.7	275 330 375 400 450 530 600 675 800 900	0.5-0.6 0.6-0.9 0.9-1.2 1.2-1.5 1.5-1.8 1.8-2.1 2.1-2.4 2.4-2.7 2.7-3.0 3.0-3.6 3.6-4.2 4.2-4.9 4.9-5.5 5.5-6.0	275 330 375 430 480 530 600 675 750 825 900 1000 1100 1200	0.5-0.6 0.6-0.9 0.9-1.2 1.2-1.5 1.5-1.8 1.8-2.1 2.1-2.4 2.4-2.7 2.7-3.0 3.0-3.6 3.6-4.2 4.2-4.9 4.9-5.5 5.5-6.0	275 300 330 350 400 450 500 550 600 675 750 825 900 1000	0.5-0.6 0.6-0.9 0.9-1.2 1.2-1.5 1.5-1.8 1.8-2.1 2.1-2.4 2.1-2.7 2.7-3.0 3.0-3.6	250 300 330 375 400 450 500 550 600 650	30-38 38-44 44-50 50-63 63-75 75-88 88-100 100-113 113-125 125-140	.45 .50 .55 .60 .70 .80 .995 1-1.1 1.1-1.2

	TABLE I ENGLISH									
Spreading Bro Conif. and and		Broad and Br	PE 2 TYPE 3 Columnar Conif. Coadleaf Conif. Greens Evergreens		TYPE 4 Shrubs and Small Trees		TYPE 5 Standard Shade Trees			
Spread (Feet)	Min. Diam. Ball (Inches)	Height (Feet)	Min. Diam. Ball (Inches)	Height (Feet)	Min. Diam. Ball (Inches)	Height (Feet)	Min. Diam. Ball (In.)	Diam. (Inches)	Min. Diam. Ball (Inches)	
1.5-2 2-2.5 2.5-3 3-3.5-3 3.5-4 4-5 5-6 6-7 7-8 8-9	11 13 15 16 18 21 24 27 32 36	1.5-2 2-3 3-4 4-5 5-6 6-7 7-8 8-9 9-10 10-12 12-14 14-16 16-18 18-20	11 13 15 17 19 21 24 27 30 33 36 40 44 48	1.5-2 2-3 3-4 4-5 5-6 6-7 7-8 8-9 9-10 10-12 12-14 14-16 16-18 18-20	11 12 13 14 16 18 20 22 24 27 30 33 36 40	1.5-2 2-3 3-4 4-5 5-6 6-7 7-8 8-9 9-10 10-12	10 12 13 15 16 18 20 22 24 26	1.25-1.5 1.5-1.75 1.75-2 2-2.5 2.5-3 3-3.5 3.5-4 4-4.5 4.5-5 5-5.5	18 20 22 24 28 32 36-38 40-42 44-48 48-54	

Examples of the types in the above table are:

- Type 1. Pfitzers Juniper, Spreading Yew, Globe Arborvitae, Cotoneaster, Rhododendron, Azalea, Pittosporum.
- Type 2. Retinospora (fast-growing upright varieties), Norway Spruce, Hemlock, Pine, Magnolia, Laurel.
- Type 3. Arborvitae (upright varieties), Juniper, Holly, Yew (upright).
- Type 4. Viburnum, Dogwood, Flowering Cherry, Hawthorn.
- Type 5. Maple, Oak, Birch.

Note: For upper limits of various sizes, the minimum sizes of balls should be proportionately increased to meet the lower limits of ball sizes for the next higher classification.

Balls with diameters less than 500 mm (20 inches) - Depth not less than 75% of diameter.

Balls with diameters of 500-750 mm (20-30 inches) incl. - Depth not less than 66 2/3% of diameter.

Balls with diameters of 775 mm-1.2 m (31-48 inches) incl. - Depth not less than 60% of diameter.

- (c) Inspection of Plant Material.
  - (1) Inspection of plant material will be made at the nursery by the Engineer, or a duly authorized representative, whenever such an examination is deemed practical, and must be in the field (or in storage houses) of the nursery supplying the material. The Department reserves the right to place identification seals on any or all plants selected.
  - (2) Approval of material on such an examination shall not be as construed as an acceptance of it. Final acceptance will not be made until the plant material is in a healthy, growing condition as provided in Article 253.14.
  - (3) With respect to inspection for plant diseases and insect infestation, an inspection certificate shall accompany each shipment and on arrival the certificate shall be filed with the Engineer.

# (d) Shipment.

- (1) Each species or variety shall be handled and packed in the manner approved for that plant, having regard for the soil and climatic conditions at the time and place of digging and of delivery, and to the time that will be consumed while in transit or delivery. All precautions that are customary in good trade practice shall be taken to ensure the arrival of the plants in good condition.
- (2) Plants shall be packed or covered in such a manner as to ensure adequate protection against damage while in transit. The roots of bare root plants shall be carefully protected with wet straw or other suitable material to ensure the arrival of the plants at destination with the roots in a moist condition.
- (3) When shipment is made by an enclosed vehicle, the vehicle shall be adequately ventilated to prevent any "heating" in transit.
- (4) Unless requested by the Engineer, only a representative amount of shrubs, seedlings or liners need to be tagged. All other stock furnished must be legibly tagged with the name or the corresponding key designation as indicated on the plans.
- (5) All material is to conform to size and grade according to the current American Standards for Nursery Stock ASA Z60.1 adopted by the American Association of Nurserymen.

# 1081.02 Perennial Plants.

- (a) Bulbs and Tubers. Bulbs and tubers shall be in a firm, healthy condition and shall be of the top or jumbo size grade. The Contractor shall furnish the Engineer a shipping ticket or label documenting that the variety, color, and size of the bulbs or tubers supplied are as specified.
- (b) Herbaceous Plants. Herbaceous plants shall be in a healthy condition with root systems developed enough to fill the pot size specified. If a pot size is not specified, plants shall be supplied potted or bare root at a minimum size of 1-year old plant of the specified species, except that bare root plants

will be acceptable only for the spring planting season. Flats or bundles of plants shall be clearly labeled by variety, and the Contractor shall furnish the Engineer a shipping ticket or label documenting that the plants supplied are as specified.

**1081.03 Sod.** Each piece of sod shall be well covered with turf grass, shall be free from noxious weeds and other objectionable plants, and shall not contain substances injurious to growth. The grass shall be cut to a length of not less than 40 mm (1 1/2 inches) nor more than 100 mm (4 inches) before the sod is cut. The sod shall be cut in rectangular pieces with its shortest side not less than 300 mm (12 inches). The sod shall not be cut less than 25 mm (1 inch) thick. This thickness measurement does not include grass.

With respect to inspection for plant diseases and insect infestation, an inspection certificate shall accompany each shipment and on arrival shall be filed with the Engineer.

- (a) Native Sod. The sod used shall be approved grass that is native to the locality of work. It shall be either nursery grown or field grown and be well rooted and approved by the Engineer prior to being cut and again before it is laid. Sod that has been grown on soil high in organic matter such as peat will not be acceptable. The consistency of adherent soil shall be such that it will not break, crumble or tear during handling and placing of the sod.
- (b) Salt Tolerant Sod.

Variety	Percent by Weight
Buffalo Grass Buchloe dactyloides	30%
Amigo fineleaf tall fescue	20%
Dawson Red fescue	15%
Scaldis hard fescue	15%
Rugby Kentucky Bluegrass	5%
Fults Pucinnellia Distans	15%

#### 1081.04 Seeds.

(a) Sampling and Testing. Each lot of seed, except Prairie Forbs, furnished shall be tested by a State Agriculture Department (including other States) or by land grant college or university agricultural sections or by a Registered Seed Technologist.

Acceptance of seeds furnished will be based on receipt and approval of a certification covering tests from each lot of seed. Certification shall consist of test reports showing the required test results of lots corresponding to the shipment and signed by the responsible personnel of the testing agency. A Registered Seed Technologist shall verify his/her signature with his/her Society of Commercial Technologists' seal.

Seeds may be sampled at destination on a random basis and tested for

#### Materials for Planting

comparison with certification and compliance with these requirements. If deviations are found, the results will be reviewed to determine if the material is acceptable for use. Major deviations may result in a requirement that each lot of material from the source in question be sampled, tested, and approved by the State Agriculture Department before further use.

- (b) Packing and Storage. Seeds shall be packed for delivery in suitable bags according to standard commercial practice. Each bag shall be tagged or labeled. If it is necessary to store the seeds after their arrival on the work site, they shall be stored in an approved weatherproof building in such a manner as to protect the seeds from deterioration and to permit easy access for inspection. The Engineer's approval of the storage building and the method of storage shall not relieve the Contractor of his/her responsibility for the quality and fitness of the seeds at the time of their use.
- (c) General Requirements.
  - (1) Variety and Origin. All seeds shall be guaranteed by the vendor to be true to name and variety. Whenever a particular origin is specified, all seeds furnished shall be guaranteed to be from that origin.
  - (2) Mixtures. Seed mixtures shall be proportioned by weight. Mixing of the individual varieties of seed to form such mixtures shall be performed under the supervision of the Engineer.
  - (3) Noxious Weed Seeds. No seeds shall be sown until they have been tested for purity and until such tests indicate that the seeds do not contain any seeds of the noxious weeds classed as "Primary Noxious Weed Seed" and not more than the maximum number per gram (ounce) sample, specified in Table II, Noxious Weeds classed as "Secondary Noxious Weed Seed".
  - (4) Hard Seeds. In determining the viable germination percent of legumes, the percent hard seed is to be added to the percent test germination; however, the percent hard seed added shall not exceed the maximum specified in Table II when planted in the fall season.
  - (5) Seed Purity. Seeds having a purity that is below the purity specified in Table II will be rejected. Seeds having a total inert matter and weed seed content greater than 20 percent of the sample in cases of bluegrass, redtop, orchard grass, brome grass, and creeping red fescue, and greater than 3 percent in all other agricultural seeds listed in Table II, will be rejected. Any sample containing more than 5 percent by mass (weight) of seed of other cultivated plants will be rejected. Seeds that fail to meet the requirements of Table II, "Maximum Weed Seed Percent" and "Remarks", will be rejected.
  - (6) Pure, Live Seed. Pure, live seed shall be defined as the sproutable seed of a specified variety and calculated as the product of the viable germination times the purity. The seed kg/ha (weights per acre) listed in Table I of Article 250.07, "Seed Mixtures", are designed to yield specific amounts of pure, live seed per hectare (acre) based on the pure, live seed percent values listed in Table II of this Article. Seed which has actual pure, live seed yield according to tests less than the intended yield will have the specified quantity adjusted to meet the intended pure, live seed yield. The adjusted weight to be sown will be calculated as follows:

Art. 1081.04

Adjusted kg/hectare (lbs./acre) =

Intended pure live seed per hectare (acre) x 100

Actual pure live seed percent

Where:

Intended pure live seed per hectare (acre) = (Table I, Article 250.07) Specific kg/hectare (lbs./acre) x Pure live seed percent (Table II, Article 1081.04)

Actual pure live seed percent :

Actual germination percent x actual purity percent

Seeds which meet the noxious weed seed and purity requirements may be sown prior to the completion of the germination test provided an additional amount of seed, specified by the Engineer, is used without additional compensation.

(7) Native Grass Mixture. The seed quantities indicated per hectare (acre) for Prairie Grass Seed in Class 4 Seeding and the Prairie Grass Seeds in Class 3 in Article 250.07 shall be the amounts of pure, live seed per hectare (acre) for each species listed. Seed which has actual pure, live seed yield according to tests less than the intended yield, will have the specified quantity adjusted to meet the intended pure, live seed yields.

Thirty days prior to the time of seeding, the Contractor shall provide for the approval of the Engineer, a written description for the Prairie Forbs seed mix showing the percentage by mass (weight) of each of the kinds of seed. This description shall also include the following:

- a. Name and location of the seed supplier.
- b. Origin and date of harvest of each of the various kinds of seed.
- c. A statement of the purity and germination of the seeds.
- The estimated number of seeds per kg (lb.) of each of the kinds of seed to be furnished.

TABLE II						
Variety of Seeds	Hard Seed Percent Maximum	Purity Percent Minimum	Pure, Live Seed Percent Minimum	Weed Percent Maximum	Secondary Noxious Weeds No. per kg (oz.) Max.Permitted*	Remarks
Alfalfa Brome Grass Clover, Alsike Clover, Crimson Clover, Ladino Clover, Red Clover, White Dutch Dawson Red Fescue Fescue, Alta or Ky. 31 Fescue, Creeping Red Fults Salt Grass Kentucky Bluegrass Lespedeza, Korean Oats Orchard Grass Redtop Ryegrass, Perennial, An Rye, Grain, Winter Scaldis Hard Fescue Timothy Vetch, Crown Vetch, Spring	0 - 30 30	92 75 92 92 92 92 97 92 75 98 75 92 75 92 92 92 92 92	89 68 87 83 89 89 88 85 72 84 88 70 78 88 83 85 84	0.50 2.00 0.30 0.50 0.30 0.30 0.10 1.00 0.10 0.50 0.50 1.50 0.50 0.5	211 (6) 175 (5) 211 (6) 211 (6) 211 (6) 211 (6) 211 (6) 105 (3) 211 (6) 70 (2) 247 (7) 211 (6) 70 (2) 175 (5) 175 (5) 175 (5) 175 (5) 175 (3) 211 (6) 70 (2)	1/ - 2/ - - 3/ - - 5/ 3/ 4/ 4/ 4/ 4/ 4/ 4/ 4/ 4/ 4/ 4/ 4/ 4/ 4/
Vetch, Winter Wheat, Hard Red Winter	15	92 92 92	83 89	1.00 1.00 0.50	105 (3) 70 (2)	4/ 4/

- 1/ Shall be grown in Kansas or farther north; shall be free from any mixture with southern or foreign seeds, blends or adulterations with screenings, frosted or damaged seeds; and shall not contain more than 0.2 percent bur or sweet clover mixture.
- 2/ Shall be free from blends or adulterations with screenings, blasted, shriveled or immature seeds.
- 3/ Shall be hulled and free from blends or adulterations with blasted, shriveled, or immature seeds.
- 4/ Shall be recleaned.
- 5/ Shall not contain more than 5 percent adulteration with Canada Blue Grass, Merion Blue Grass, or other hybrids or varieties of blue grass.
- 6/ Shall be scarified.
- No primary Noxious Weeds are permitted.

## 1081.05 Topsoil and Compost.

(a) Topsoil. Topsoil shall be loamy soil from the A horizon of soil profiles of local soils. It must have an organic content between 1 and 10%. It shall be relatively free from large roots, sticks, weeds, brush, or stones larger than 25 mm (1 inch) in diameter, or other litter and waste products. At least 90 percent must pass the 2.00 mm (No. 10) sieve and the pH must be between 5.0 and 8.0.

Topsoil shall be capable of supporting and germination of vegetation.

(b) Compost. Compost shall be thoroughly decomposed organic waste produced at an IEPA registered compositing facility. All compost shall be approved by the Engineer. This compost shall have no glass or metal shards present. Any plastic or other man made material shall be no larger than 4 mm and sieved out to be less than 1% of the total dry weight. A copy of the compost test results and certification of IEPA registration must be provided to the Engineer with each shipment of compost.

Compost shall be capable of supporting and germination of vegetation.

**1081.06 Mulch.** Mulch material for seeding and planting shall be non-toxic to vegetation and to the germination of seed and shall be approved by the Engineer.

- (a) Seeding. Mulch material for seeding shall be as follows:
  - Straw. Straw shall be stalks of wheat, rye, oats or other approved straw, and shall be air-dried.
  - (2) Hydraulic Mulch. Hydraulic mulch shall be virgin or recycled wood cellulose or paper fibers containing no growth or germination inhibiting factors. Hydraulic mulch shall disperse evenly and rapidly and remain in slurry when agitated with water. The slurry shall be green in color to allow visual metering of its application and, when sprayed uniformly on the surface applied to, shall form an absorbent cover allowing percolation of water to the underlying surface. Hydraulic mulch shall be packaged in moisture resistant packages or bags with the net quantity of the packaged material plainly shown on each such package. The wood cellulose or paper fibers shall not be water soluble and shall comply with the following properties when tested according to the procedures outline in Federal Specification O-P-166. The recycled wood cellulose or paper fibers shall be relatively free of glossy papers.

Moisture content, as received basis, percent by mass (weight), maximum	15
Organic matter, wood, fiber ovendried basis, percent by mass (weight), minimum	95
Н	4.3-8.5
Water holding capacity, oven dried basis, percent by mass (weight), minimum	400

(3) Chemical Mulch Binder. Chemical mulch binder shall be a commercially available product specifically recommended by the manufacturer for use as a mulch stabilizer.

The mulch binder shall be nonstaining and nontoxic to vegetation and the environment. It shall disperse evenly and rapidly and remain in suspension when agitated in water. The mulch binder and water

#### Materials for Planting

suspension or slurry shall be green in color to allow visual metering of its application.

Prior to use of the mulch binder, the Contractor shall submit a notarized certification by the manufacturer stating that it meets these requirements. Chemical mulch binder shall be packaged, stored, and shipped according to the manufacturer's recommendations with the net quantity plainly shown on each package or container.

- (b) Planting. The mulch material for planting shall consist of shredded tree bark, wood chips, or other approved organic mulch as specified in the plans. The mulch must be approved by the Engineer prior to placement.
- 1081.07 Agricultural Ground Limestone. Agricultural Ground Limestone shall contain particles ground sufficiently fine so that essentially all material pass a 4.75 mm (No. 4) sieve and is graded relatively uniform through the 2.36 mm, 600  $\mu$ m and 250  $\mu$ m (Nos. 8, 30 and 60) sieves. Approved sources of Agricultural Ground Limestone shall be tested by the Department of Agriculture and rated with a source correction factor.
- **1081.08 Fertilizer.** Fertilizer shall be ready-mixed material of an analysis specified on the plans and as directed by the Engineer. In cases where a single nutrient is requested, the analysis shall be optional, provided that it carries sufficient filler to ensure adequate distribution of the nutrient.

The following information shall be shown on the fertilizer bag or package or on tag:

- (a) An attached
  - (1) Name and address of manufacturer
  - (2) Name, brand or trademark
  - (3) Number of net kilograms (pounds) of ready-mixed material in the package
  - (4) Chemical composition or analysis
  - (5) Guarantee of analysis

If a brand or grade of fertilizer is delivered in the bulk, a written statement having the above listed information must accompany each load.

- (b) Custom mixed fertilizers shall have a written statement containing the following information with each load:
  - (1) Weight of each commercial fertilizer used in the custom mix.
  - (2) The guaranteed analysis of each commercial fertilizer used in the custom mix.
  - (3) Total weight of fertilizer delivered in each load.
  - (4) The manufacturer of each of the commercial fertilizers used in the custom mix.
  - (5) Guaranteed analysis of each load to be stated as follows:
    - a. Percent of total Nitrogen (N)

- b. Percent of total available Phosphoric (P<sub>2</sub>O<sub>5</sub>)
- c. Percent of total Soluble Potash (K<sub>2</sub>O)
- (6) Name and address of the person selling the fertilizer.

## 1081.09 Peat Moss.

- (a) Peat moss shall be partially decomposed fibrous or cellular stems and leaves of any of several species of sphagnum mosses, and shall conform to the following requirements:
  - (1) Texture and Composition. Its texture may vary from porous fibrous and spongy fibrous, and it shall be either crumbly or compact, but fairly elastic and substantially homogeneous. It shall be free from decomposed colloidal residue, excessive woody materials (roots and stems), and shall be essentially dark brown in color. Shredded particles shall not exceed 6 mm (1/4 inch) in size.
  - (2) Acidity. The pH value shall be not less than 3.2 and not greater than 5.5, at approximately 25 °C.
- (b) Packing. The air-dried peat moss shall be packed in bales of the type, size, and kind commonly used. Damaged bales will not be accepted.

The peat moss shall be packed in the bales at a compression ratio of at least 2 to 1. Each bale shall be clearly marked with the type of peat moss, the brand name, the country of origin, the cubic meter (cubic feet) compressed size, the compression ratio used, and the approximate mass (weight) of the bale. Each shipment shall be accompanied by a certificate stating that the peat moss meets the specified requirements.

## 1081.10 Special Erosion Control Materials.

(a) Excelsior Blanket. Excelsior blanket shall consist of a machine produced mat of wood excelsior of 80 percent 150 mm (6 inches) or longer fiber length. The wood from which the excelsior is cut shall be properly cured to achieve adequately curled and barbed fibers.

The blanket shall be of consistent thickness, with the fiber evenly distributed over the entire area of the blanket. The excelsior blanket shall be covered on the top side with a 90 day biodegradable extruded plastic mesh netting having an approximate minimum opening of 16 x 16 mm ( $5/8 \times 5/8$ ") to an approximate maximum opening of 50 x 25 mm ( $2 \times 1$ "). The netting shall be entwined with the excelsior mat for maximum strength and ease of handling.



The excelsior blanket shall comply with the following Specifications:

Minimum width, mm (inches),	
minus 25 mm (1 inch)	600 mm (24)
Minimum mass (weight) per m <sup>2</sup> (sq. yd.), kg (lbs.),	` ,
minus 10 percent	0.43 (0.8)
Minimum length of roll, m (ft.), approximately	

The excelsior blanket shall be smolder resistant and shall withstand the following test:

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The excelsior blanket specimen shall not flame or smolder for more than a distance of 300 mm (12 inches) from a spot where a lighted cigarette is placed on the surface of the blanket.

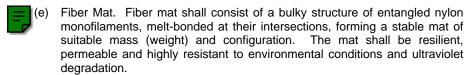
Certification. The manufacturer shall furnish a certification with each shipment of excelsior blanket stating the number of rolls furnished and that the material complies with these requirements.

(b) Knitted Straw Mat. Knitted straw mat shall be a machine-assembled blanket whose primary component is clean, weed-free straw from agricultural crops. The straw must be evenly distributed throughout the blanket to a loose thickness of approximately 13 mm (1/2 inch) with a permissible variation of ± 3 mm (1/8 inch). The top side of the blanket shall be covered with biodegradable plastic mesh of 10 x 10 mm (3/8 x 3/8") square openings with a permissible variation of ± 3 mm (1/8 inch) and shall be substantially adhered to the straw by a knitting process using biodegradable thread. The plastic mesh shall degrade within 90 days.

The blanket shall be supplied in a protected rolled mat form of 2-m (6 1/2-ft.) width and the average dry mass (weight) shall not be less than 0.27 kg/m<sup>2</sup> (0.50 lbs. per sq. yd.).

Certification. The manufacturer shall furnish a certification with each shipment, stating the number of rolls furnished and that the material complies with these requirements.

- (c) Staples. Staples shall be made from No. 11 gage or heavier uncoated black carbon steel wire of sufficient stiffness for soil penetration. They shall be of the "T" or "U" configuration with pointed ends, 25 to 50 mm (1 to 2 inches) wide at the top and a minimum overall length of 150 mm (6 inches) from top to bottom. The staples shall be packaged in cartons.
- (d) Wood Stakes. Hardwood blanket anchors shall be approximately 180 mm (7 inches) long from neck of hook to tip of anchor. The wood shall not break during installation. The anchor shall have a 13-mm (1/2-inch) curving hook to hold the blanket in place.



The mat shall comply with the following physical properties:

Material Type - Nylon 6 plus a Min. Content of 0.5% by weight of Carbon Black.

Filament Diameter mm (inch), Min	0.41 (0.75) 18 (0.70) 965 (38) 100 (109)
Tensile Properties*	
Strength N/mm (lb./inch), Min. Length Direction	1.4 (7.8) 0.8 (4.4)
Elongation %, Min. Length Direction Width Direction	50 50
Resiliency**	
30 min. Recovery %, Min	80

<sup>\*</sup>ASTM D 1682 Strip test procedure modified to obtain filament bond strength to indicate tensile properties of Fiber Mat.

<sup>\*\*</sup>Compression load cycling of 690 kPa (100 psi) on 50 x 50 mm (2 x 2") sample size, crosshead speed of 50 mm (2") per minute.



Certification. The manufacturer shall furnish a certification with each shipment of fiber mat stating the number of rolls furnished and that the material complies with the requirements of the Specification.

## 1081.11 Bracing.

(3 cycles)

- (a) Steel Posts. Steel posts for bracing shall be of a type normally used for agricultural fencing; have a steel anchor plate welded or riveted to each post approximately 450 mm (18 inches) from the bottom of the post, be 1.8 m (6 ft.) minimum in length, and shall weigh not less than 1.5 kg/m (1 lb./ft.). The post shall be finished with a suitable paint of acceptable color or galvanizing unless specified for use as selective mowing stakes. When specified for selective mowing stakes, the steel posts shall be finished in an acceptable color of green paint. For delineating seedling plantings, the posts shall have the top 250 mm (10 inches) painted with 2 coats of State equipment orange paint. For delineating native grass, wildflower and ornamental herbaccons plantings, the top 250 mm (10 inches) of the posts shall be painted with 2 coats of white paint.
- (b) Earth Anchors. Earth anchors shall consist of a metal rod with attached spiral or helical metal anchor plate; shall conform to the following minimum requirements:

Length: 1 m (42 inches); rod diameter: 16 mm (5/8 inch); eye opening: 25 mm (1 inch); anchor plate diameter: 100 mm (4 inches).

**1081.12 Weed Barrier Fabric.** Weed barrier fabric shall be an approved black, ultraviolet light resistant, non-woven geotextile fabric with a minimum mass (weight) of 60 g/m<sup>2</sup> (1.75 oz./sq. yd.).

## 1081.13 Temporary Erosion Control Materials.

- (a) Bale Stakes. Bale Stakes shall be 1.2 m (4 ft.) minimum in length and be either of sound wood 25 mm (1 inch) minimum for one dimension, metal according to Article 1006.28(d) or painted metal posts.
- (b) Fence Stakes. Fence stakes, except for silt filter fence, shall be 2.4 m (8 ft.) minimum in length metal stakes according to Article 1006.28 (d) or painted metal posts.
- (c) Bales. Bales shall be either hay or straw compacted and adequately bound to an approximate size of 300 x 450 x 900 mm (12 x 18 x 36").
- (d) Fence. Fence shall be a minimum of 1.2 m (4 ft.) in height and may be either snow fence, flexible wooden slat fence, woven wire, or any similar material approved by the Engineer.
- (e) Aggregate. Aggregate shall include any locally available coarse aggregate, stone, broken brick, broken concrete, or riprap meeting the approval of the Engineer. The gradation required will be specified by the Engineer to control velocity and flow.



## **SECTION 1082. PREFORMED BEARING PADS**

**1082.01 Fabric Bearing Pads.** Fabric bearing pads shall consist of a fabric and rubber body made with new unvulcanized rubber and unused fabric fibers.

The rubber body shall be a natural rubber compound known as natural polyisoprene or synthetic rubber known as polychloroprene.

The average surface hardness expressed in standard rubber hardness shall be  $80 \pm 10$  Shore A Durometer.

The ultimate breakdown limit of the pad under compressive loading shall be no less than 48 MPa (7000 psi) for the specified thickness without splits or deformations exceeding 10 percent of thickness after removing the load.

The pads shall be furnished to specified dimensions with all dowel holes accurately located. The thickness of fabric bearing pads shall be as shown on the plans within a tolerance of  $\pm$  1.5 mm (1/16 inch).

#### **SECTION 1083. ELASTOMERIC BEARINGS**

- **1083.01 Description.** Elastomeric Bearings shall consist of laminated elastomeric pads or assemblies of laminated elastomeric pads with externally bonded structural steel bearing plates, structural steel top bearing plate, and required stainless steel and TFE sheets, as shown on the plans and as specified.
- The bond of steel components to and within the elastomeric pads shall be continuous throughout the plan area with no voids or air spaces greater than 2.5 mm (0.10 inch) within the bonding material. Bonding of TFE sheets shall be done as

noted on the plans. The bearing assemblies shall be furnished as a complete unit from one manufacturing source. Shop drawings of the bearing assemblies shall be submitted to the Engineer.

**1083.02 Elastomeric Materials.** The elastomeric materials shall be according to AASHTO M 251 (60 durometer) with the following exceptions:

- (a) Durometer hardness shall be  $55 \pm 5$  shore points.
- (b) Bond strength shall be a minimum of 7 N/mm (40 lbs./inch) and an adhesion failure of R-80 (ASTM D 429, B). The adhesion failure requirement is waived if bond strength equals or exceeds 14 N/mm (80 lbs./inch).
- (c) For natural rubber the duration of test to determine ozone resistance (ASTM D 1149) shall be 100 hours.

**1083.03 TFE Material.** The TFE resin shall be 100 percent virgin material, premium grade, meeting the requirements of ASTM D 1457. The TFE sheet (polytetrafluoroethylene sheet, premium grade) shall consist of pure TFE resin, compression molded, and skived into sheets of the required thickness. The finished sheet shall conform to the following physical properties:

ASTM <u>Standard</u>	Physical Properties	
D 638M (D 638 D 792 D 2240	) Tensile strength min, MPa (psi) ) Elongation, min % Specific Gravity Hardness, Durometer D	19 (2800) 200 2.15-2.20 50-65
D 621	Deformation Under Load 23 °C/690kPa/24 hrs. (73 °F./100 psi/24 hrs.), % 50 °C/8.3 MPa/24 hrs. (122 °F/1200 psi/24 hrs.), 23 °C/13.8 MPa/24 hrs. (73 °F/2000 psi/24 hrs.), Water Absorption, % Static Coef. of Friction at 3450 kPa (500 psi) bearing pressure	% 15 max. 0.01 max.
D 429, B	on stainless steel, max  Adhesion to Steel Peel Strength, N/mm (lbs./in.)	0.07 4.4 (25)

**1083.04** Stainless Steel Sheets. The stainless steel sheets shall be of the thickness specified and shall conform to ASTM A 240, Type 304. The sliding surface shall have a Type 2B finish or smoother as per the American Society of Metals.

#### 1083.05 Structural Steel.

- (a) Structural Steel Bearing Plates. The structural steel bearing plates shall conform to the requirements of AASHTO M 270M Grade 250 (M 270, Grade 36).
- (b) Internal Steel Laminates. The internal steel laminates for the laminated elastomeric bearings shall be rolled mild steel sheets conforming to AISI 1015 - 1025, inclusive, ASTM A 366M (A 366) or A 569 for less than 5-mm (3/16-inch) thick sheets, or AASHTO M 270M, Grade 250 (M 270, Grade

- 36) or ASTM A 283M (A 283) Grade D for 5-mm (3/16-inch) and thicker sheets.
- (c) Shear Restrictor Pin. The shear restrictor pin, when required, shall be press fit into the bearing plate and shall be alloy steel, quenched, and tempered to a minimum yield strength 1450 MPa (210,000 psi) (or RC hardness of 50 to 55).
- (d) Threaded Stud. The threaded stud, when required, shall conform to the requirements of AASHTO M 164M (M 164).

**1083.06 Fabrication Requirements.** Laminated elastomeric bearings shall be individually molded to the required size. Corners and edges may be rounded with a radius at the corners not exceeding 10 mm (3/8 inch) and a radius at the edges not exceeding 6 mm (1/4 inch). All edges of the embedded steel laminates, including at the laminate restraining devices and around holes and slots shall be covered with not less than 3 mm (1/8 inch) and not more than 6 mm (1/4 inch) of elastomer. No rubber flash will be permitted on the edges of TFE bearing surfaces. All burrs or raised edges along the perimeter of the TFE surface shall be removed before shipment. With the exception of the above elastomer cover tolerances, all dimension tolerances shall be accoring to AASHTO M251.

Structural steel bearing plates shall be fabricated according to Article 505.04. Prior to shipment of the bearing assemblies, the exposed edges and other exposed portions of the structural steel bearing plates shall be cleaned and painted in accordance with Articles 506.03 and 506.04. Painting shall be with the zinc-silicate primer according to Article 1008.22. During the cleaning and painting, the stainless steel and TFE sheet sliding surfaces and the elastomer shall be protected from abrasion and paint.

**1083.07 Testing and Acceptance.** The rubber laminates shall be of uniform integral units, capable of being separated by mechanical means into separate, well-defined elastomeric layers. The ultimate breakdown limit of the elastomeric bearing under compressive loading shall be not less than 13.8 MPa (2000 psi).

The bearing manufacturer shall load test each completed laminated elastomeric bearing pad assembly prior to shipment. The bearings shall be loaded to 10.4 MPa (1500 psi) and under this loading shall exhibit relatively uniform bulging of the rubber layers on all sides and shall show no bond loss or edge splitting. Bearing assemblies under this loading showing nonuniform bulging from one side of the pad to the other, nonuniform bulging along any vertical face of a pad, bulging extending across the specified location of one or more of the internal steel laminates or edge splitting shall be replaced. Nonuniform bulging from one side of the pad to the other may be an indication of lateral misalignment of the internal steel laminates and would not be cause for replacement if probing shows that the edge cover of the laminates are within the specified tolerances. Nonuniform bulging along any vertical face of the pad may be an indication of vertical misalignment of the laminates and would not be cause for replacement if measurement of the bases of the nonuniform bulges show that the thickness of the elastomer layers are within the specified ±20% tolerance. Bulging across the specified location of one or more laminates indicates missing laminates or lack of bond and pads exhibiting these characteristics shall always be replaced.

The Contractor shall furnish certified copies of the bearing manufacturer's test reports on the physical properties of the component materials for the bearings to be furnished and a certification by the bearing manufacturer that the bearings furnished have been load tested and conform to all requirements.

When directed by the Engineer, the Contractor shall furnish random samples of component materials used in the bearings for testing. In addition, when requested in writing by the Engineer, the Contractor shall furnish an additional project bearing assembly to the Department for testing. When the additional bearing assembly is requested, the Engineer retains the right to select the bearing assembly for testing at random from the project lot. The Contractor will be paid for the additional bearing assembly as specified in Article 503.22. If the bearing assembly tested is found to be unacceptable, 2 additional bearing assemblies will be tested. If both are acceptable, the lot will be accepted. If either of the additional 2 bearing assemblies are unacceptable, the lot will be rejected. The Contractor shall have a new lot produced, including one additional test bearing. No payment will be made for the original failed bearing assembly or any subsequent test assemblies.

## SECTION 1084. TRAFFIC CONTROL DEVICES AND CONSTRUCTION SIGNS

**1084.01** Flashing and Steady Burning Barricade Lights. Barricade lights shall consist of a metal or plastic case, transistorized electrical circuit and head. Lights shall be maintained so as to be visible on a clear night from a distance of 900 m (3000 ft.). Type B lights, when required for daylight operations, shall be maintained so as to be visible on a sunny day from a distance of 300 m (1000 ft.) when viewed without the sun directly on or behind the light. All lights shall meet the requirements of the Institute of Transportation Engineers Standard for Flashing and Steady-Burn Barricade Warning Lights. Lights are classified as follows:

Type A - Low intensity flashing Type B - High intensity flashing

Type C - Steady burning

- (a) Internal Power (Batteries): The batteries shall be provided by the Contractor but shall not be installed until the light is ready to be used. The light shall be constructed so when the batteries are installed, the terminals are on top of the battery. The batteries shall be contained within the case. The battery terminals shall be either plug or spring type. All electrical connections shall be of noncorrosive material.
- (b) External Power: If external power is supplied, then all power connections shall be hermetically sealed. The method of installing these lights shall be approved by the Engineer. There shall be an isolated fuse for each light. The fuse shall be located near the pavement edge between the light and the power source and shall be installed so that if one light is damaged, causing a short circuit, all lights will not be extinguished. In all cases, an additional emergency power supply shall be present for operation in the event of power failure. A portable generator may be used as primary or secondary power source.
- (c) Case: The case for the battery shall be constructed of aluminum, galvanized steel, or plastic of an orange, white, or metallic color. The case shall have a vandal-proof fastener on either or on both the side and back, suitable for mounting on barricades or signs. The case shall be weatherproof.
- (d) Photoelectric Cell: All Types A and C lights shall be equipped with a switching circuit activated by a photoelectric cell. Type B lights may also be equipped with a photoelectric cell when 24-hour operation is not required

in the contract.

(e) Testing and Marking: All lights shall be tested and certified as meeting these requirements by an independent laboratory. Two copies each of the full testing report and certification shall be provided to the Engineer. The report shall specify the lens manufacturer and part number, the circuit manufacturer and part number, the bulb number, and the minimum operating voltage at which the unit meets the intensity requirements of these Specifications. Each light shall be plainly and permanently marked with the type, manufacturer's name, and model number.

## 1084.02 Reflective Sheeting.

(a) Channelizing Devices. At the time of manufacturing, the reflective sheeting used on barricades and vertical panels as shown on Highway Standard 702001 shall have the following initial minimum coefficient of retroflection expressed as average candelas per lux per m<sup>2</sup> (candelas per foot candle per sq. ft.) of material. Measurements shall be conducted according to ASTM E 810.

Color	Observation Angle 0.2 Entrance Angle		Observatio 0.5 Entrance	
Silver/White Orange	-4 140.0 42.0	+30 60.0 15.0	-4 50.0 14.0	+30 28.0 8.0

The reflective sheeting on drums shall conform to the requirements for barricades and vertical panels except that drums with steady-burn lights shown for lane closure tapers and runarounds on Highway Standards 701401, 701421 and 701416, and flexible delineators shown on Highway Standard 702001 shall conform to the following initial minimum coefficient of retroreflection.

Color	Observation Angle 0.2 Entrance Angle		Observatio 0.5 Entrance	J
Silver/White Orange	-4 250.0 100.0	+30 100.0 30.0	-4 95.0 40.0	+30 50.0 15.0

Sheeting color and surface shall be according to the requirements contained in Article 1084.02(b).

(b) Construction and Maintenance Signs. All orange signs used shall be

fluorescent orange in color and meet the initial minimum brightness values of the orange sheeting shown in the following table. The sign face shall consist of reflective sheeting with the appropriate screened message. The reflective sheeting shall consist of glass spherical lens elements or plastic microprismatic elements covered with a transparent plastic film having a smooth, sealed surface, except that a rectangular pattern may be embossed into the film. The sheeting shall be weather resistant.

At the time of manufacturing, the reflective sheeting shall have the following initial minimum coefficient of retroreflection at 0.2 and 0.5 divergence expressed as average candelas per lux per m<sup>2</sup> (candelas per foot candle per sq. ft.) of material. Measurements shall be conducted according to ASTM E 810.

Color	Observation Angle 0.2 Entrance Angle		Observatio 0.5 Entrance	J
Red Silver/White Yellow Orange	-4 45.0 90.0 60.0 100.0	+30 25.0 40.0 30.0 30.0	-4 15.0 41.0 25.0 40.0	+30 10.0 21.0 13.0 15.0

The sheeting color shall conform to the appropriate standard color tolerance chart issued by the U.S. Department of Transportation, Federal Highway Administration.

The sheeting surface shall be smooth and flat, easily cleaned, have satisfactory wet performance, and exhibit 85° gloss-meter rating of not less than 40 when tested according to the Test for Specular Gloss, ASTM D 523. The sheeting surface shall be readily processed and compatible with recommended transparent and opaque process inks and show no loss of the color coat with normal handling, cutting and applications.

**1084.03 Temporary Rumble Strips.** The rumble strip shall be black in color, formed of high strength polycarbonate. The strip shall be of one-piece construction with 2 channels on the underside for flexibility and proper adhesive bondage. The channels shall be interconnected at four or more locations to permit the bonding material to flow from one channel to the other. There shall be at least 6 weep holes through one or both channels to the upper surface of the strip and at least 4 through the leading edge of the strip to prevent air voids between the strip and the bonding material.

The rumble strip shall be capable of supporting a load of 2700 kg (6000 lbs.). The load capacity shall be determined by placing a strip over the open end of a 25 mm (1 inch) high vertically-positioned hollow metal cylinder having an internal diameter of 75 mm (3 inches) and a wall thickness of 6 mm (1/4 inch). The load shall be applied slowly through a 25 mm (1 inch) diameter by 25 mm (1 inch) high metal rod centered on the top flat portion of the strip. No weep holes shall be in the compression area. Breakage or significant permanent deformation of the strip shall

## Traffic Control Devices and Construction Signs

Art. 1084.03

constitute failure. Other similar designs may be used with the approval of the Engineer.

**1084.04 Construction and Maintenance Signs.** All signs used for temporary traffic control shall meet the approval of the Engineer. The sheeting shall be mounted on rigid material such as aluminum or exterior grade plywood. Signs utilizing a base of fabric, fiberboard, or other highly flexible or frangible material will not be permitted, except signs having a reflective sheeting face bonded to a durable plastic or fabric base will be permitted, (a) in work zones with posted speeds above 45 mph when workers are present to maintain the devices and (b) in all work zones having posted speeds of 45 mph or less.

#### **ELECTRICAL**

#### **SECTION 1085. ELECTRICAL MATERIALS**

- **1085.01 General.** Electrical materials or equipment which are similar or identical shall be the product of the same manufacturer. Electrical materials and equipment shall bear the UL label whenever such labeling is available.
- **1085.02** Splicing and Termination of Electric Cable. Splices in electrical cables shall be made with materials which are compatible with conductors, insulations, and any jackets of the associated cables.
  - (a) Roadway Lighting. Individual conductors, including ground conductors, shall be terminated with compression terminals sized appropriately for the given connection. The connectors shall be copper and comply with UL Standard 486A. The terminals shall be clearly marked with the wire size and die index. All compression terminals shall be installed with the proper tool and die for crimping. Grounding conductors shall be connected to poles, sign structures, and the like using materials specifically listed for the applicable grounding. Connections at metal boxes or enclosures shall be made by means of a suitable grounding screw used for no other purpose or by a listed grounding device. Splices for multiple conductors shall be copper compression joint sleeves. Copper compression joints (sleeves) shall be made of tin plated copper and be UL listed for 600-volt applications and shall be of the type suitable for a range of conductor combinations.

The end caps shall have a post-shrink wall thickness not less than the following:

Initial Inside Diameter		Post-Shrink Wall	<b>Thickness</b>
mm	(Inches)	mm	(Inches)
13	0.50	1.78	0.070
19	0.75	2.03	0.080
25	1.00	2.41	0.095
29	1.15	2.41	0.095
38	1.50	2.54	0.100
50	2.00	2.67	0.105

- (1) Wiring Identification Markers.
  - a. Cloth Tape Wire Markers. Wire identification shall be made by the application of self-sticking wire markers, wrapped around the wire. The markers shall have black characters not less than 8 mm (5/16-inch) high on a white or yellow background. Markers shall be in strips not less than 38 mm (1 1/2 inches) long and shall be made of a high-tack cloth tape with printing protected by a clear, permanent overcoating.
  - b. Clip-On Wire Markers. Clip-on wire markers shall be white with black lettering. The individual letters shall interlock to keep the letters aligned. Wire markers shall meet Military Specifications MIL-H-5606 and MIL-L-7808. The proper size of wire markers shall be used to prevent slipping of the markers on the cable.
- (2) Electrical Tape. Electrical tape shall be all weather vinyl plastic tape resistant to abrasion, puncture, flame, oil, acids, alkalies, and

#### **Electrical Materials**

weathering, conforming to Federal Specification HH-I-595. Thickness shall not be less than 215 mm (8.5 mils) and width shall not be less than 20 mm (3/4-inch).

#### 1085.03 Fuseholders and Fuses.

- (a) Standard Fuseholders.
  - (1) Each fuse holder shall consist of a two-section unit with a molded plastic housing designed to hold small-dimension cylindrical fuses of the type required. Each section shall be permanently etched with line and load side designations. A captive nut on one section shall mate a threaded portion of the other section and the unit shall have an "O" ring which shall provide a water and vapor-tight seal when the sections are joined.

The terminals and the contacts in the fuseholder shall be made of annealed copper. The contacts shall be spring loaded to exert contact pressure on mating parts. Fuse holders shall be rated for 30 amperes at 600 volts.

Wires shall attach to the fuse holder by a crimping operation except that connection of No. 2 wires to breakaway fuse holder receptacles may be via a set screw connection. Each fuse holder shall be of a size proper for the wires to be attached. The assembly shall be provided with insulating boots.



- (2) Fuse holders for neutral conductors shall have a permanently installed solid neutral conductor and a white plastic coupling nut and screw section.
- (3) Fuse holders used in multi-pole applications, up to 30-ampere size, shall be of the multipole type so that all phase conductors are disconnected at the same time.
- (b) Quick Disconnect Fuseholders. Quick disconnect type fuse holders shall be as specified for standard fuse holders with the following additional features:
  - (1) The fuse holder shall be capable of disconnecting upon sufficient tension in the connected wires, as in a pole knockdown.
  - (2) The fuse shall remain enclosed in the de-energized portion of the fuse holder upon disconnection. The fuse shall not be utilized as the disconnection means; a separate plug and receptacle shall be utilized for the disconnection means.
  - (3) The fuse holder assembly shall mate a line-side quick disconnect receptacle. Line side wires shall attach to the receptacle by crimping operation.
- (c) Fuses for installation within fuse holders for protection of lighting branch circuits shall be small-dimension cylindrical fuses of the dual element time-delay type with current limiting characteristics. The fuses shall be rated for 500 volts AC and shall have a UL listed interrupting rating of not less than 10,000 rms symmetrical amperes at rated voltage.

Fuses for luminaires shall be rated at 300% of the starting or operating

current whichever is greater, but in no case greater than the branch circuit conductor ampacity.

## 1085.04 Highway Lighting Grounding.

- (a) General.
  - Grounding conductors shall be copper and shall be insulated in a manner as specified for the associated phase conductors.
  - (2) Ground rods shall be copper-clad steel with a minimum copper thickness of 0.3 mm (10 mils) and UL listed 467. Ground rods shall be one piece copper-clad steel rods not less than 16 mm (5/8 inch) in diameter and 3 m (10 ft.) long.
  - (3) If the measured resistance to ground exceeds 10 ohms, additional ground rods and access wells shall be provided to reduce the ground resistance to 10 ohms or less.
- (b) Highway Lighting. Ground Rod access wells be constructed of PVC or composite polyester resin/fiberglass material with a diameter of 200 mm (8 inches) to 300 mm (12 inches), a length of 900 mm (36 inches) and a cast iron or composite polyester resin/fiberglass lid, secured via stainless steel hardware. Connections to the ground rod shall be exposed within the access well and made via exothermic welds.

#### 1085.05 Pole/Unit Identification.

- (a) Roadway Lighting Unit.
  - (1) The letters and numerals for 18 m (60 ft.) and less mounting height lighting units and underpass lighting units shall be 100 mm (4 inches) high, black, series "D" as described in the Federal Highway Administration's "Standard Alphabets for Highway Signs". Placement of numbers shall be as shown on the plans. The placement of the numbers shall be coordinated with the accident reference marker and handhole door as applicable. The letters and numerals shall be screened on silver-white, pressure sensitive, reflective, 114 mm (4-1/2 inch) by 100 mm (4 inch), Type A sheeting according to Section T 602.01 "Reflective Sheeting" in Standard Specifications for Traffic Control Items. An alternate color scheme, such as black on yellow, shall be used as directed by the Engineer or indicated in the plans when the lighting system is not maintained by the Illinois Department of Transportation.



- (2) The letters and numerals for poles of a mounting height equal to and greater than 21 m (70 ft.) shall be 225 mm (9 inches) high by 200 mm (8 inches) wide. The material of the decals and placement of numbers shall be as shown on the plans.
- (3) The letters and numerals for illuminated signs shall be 225 mm (9 inches) high by 200 mm (8 inches) wide. The material of the decals and placement of numbers shall be as shown on the plans.
- (4) Circuit identification for wood poles shall be made by the use of weather-resistant reflective letter tags in vertical slide-in holders. Letter tags shall be reflective, black on yellow, with characters 75 mm (3-inches) high on tags nominally 65 x 90 mm (2 1/2 by 3 5/8 inches)

#### **Electrical Materials**

in size. Slide-in holders shall be aluminum and shall have both ends crimped after tags are inserted. The holders shall be attached to the poles with 38 mm (1 1/2-inch) aluminum nails as recommended by the tag manufacturer.

#### 1085.06 Miscellaneous Wire.

(a) Roadway Lighting (Pole Wire).

Pole wire shall be sized No. 10, rated 600 volts, RHW/USE, and have copper conductors, stranded in conformance with ASTM B 8. Pole wire shall be insulated with cross-linked polyethylene, (XLP) insulation or ethylene propylene (EPR) insulation with a chloroxulfanated polyethylene jacket.

Color coding of the pole wire shall be via solid insulation color. Neutral wires shall be white and phase conductors shall be color coded red or black as appropriate to match the associated branch circuit conductors. Cable identification marking shall be visible in a contrasting color.

**1085.07 Lamps.** The lamps in all luminaires and traffic signal heads shall conform to ANSI requirements.

- (a) High Pressure Sodium Vapor Lamps.
  - (1) The lamps shall be of the clear type and shall have a color of 1050 to 2100° Kelvin.
  - (2) At half of the average rated lamp life, the mean output lumens shall not be less than 90% of initial lumen output.
  - (3) High pressure sodium lamps shall be suitable for any burning position.
  - (4) High pressure sodium lamps shall meet or exceed the following characteristics:

Lamp Wattage	Rated Life	Initial Lumen Output	<u>Lamp Voltage</u>
(Watts)	(Hours)	(Lumens)	(Volts)
35	16.000	2.250	52
	16,000	2,250	-
50	24,000	4,000	52
70	24,000	5,800	52
100	24,000	9,500	55
150	24,000	15,000	100
200	24,000	22,000	100
250	24,000	27,500	100
310	24,000	37,000	100
400	24,000	50,000	100
750	16,000	110,000	120
1000	24,000	140,000	250

- (b) Low Pressure Sodium Vapor Lamps.
  - (1) Lamps shall be of the clear type with an internal coating reflect infrared radiation back to the discharge tube.
  - (2) Mean lumen output shall be not less than initial lumen output.

- (3) Lamps shall have insulating shields at the ends of arc tubes to control lamp wattage rise and improve lamp life characteristics.
- (4) Low pressure sodium lams shall meet or exceed the following characteristics:

Lamp Wattage (Watts)	Rated Life (Hours)	Initial Lumen Output (Lumens)	
18	14,000	1,800	I
35	18,000	4,800	j
55	18,000	8,000	j
90	18,000	13,500	j
135	18,000	22,500	j
180	18,000	33,000	j

- (c) Metal Halide Lamps.
  - (1) The lamps shall be of the clear type and shall have a color of 3200 to 3800° Kelvin.
  - (2) At 40% of the average rated lamp life, the mean lumens shall not be less than 80% of initial lumen output.
  - (3) Lamps shall be suitable for the burning position orientation of the luminaires for which they are supplied.
  - (4) Metal halide lamps shall meet or exceed the following characteristics:

Lamp Wattage (Watts)	Rated Life (Hours)	Initial Lumen Output (Lumens)
70	7,500	5,500
100	15,000	9,000
150	15,000	13,000
175 Vertical	10,000	16,000
175 Horizontal	6,000	12,000
250	10,000	20,500
400	20,000	40,000
1,000 Vertical	12,000	110,000
1,000 Horizontal	12,000	107,800

- (d) Fluorescent. Fluorescent lamps for sign lighting shall be 800 ma, rapid start, high output, cool white, Type F72T12/CW/HO with an average rated life of 12,000 hours and a mean lumen output of 5,520 lumens. All fluorescent lamps shall be capable of starting and operating at a minimum temperature of -30 °C (-20 °F.).
- (e) Incandescent. Incandescent lamps shall be a type having an average rated life of 8,000 hours. A 135 watt lamp shall produce 1,750 lumens and 54 watt lamps shall produce 595 lumens. Other lamps shall be of the extended service type of the wattage indicated.

**1085.08 Fasteners and Hardware.** Fasteners used to mount conduit supports, boxes, and other items attached to the structure shall be suitable for the weight supported and shall be compatible with the structure material. Wood screws shall be used for wood, toggle bolts shall be used for hollow masonry, expansion bolts or

power-set studs shall be used for solid masonry or concrete, and clamps shall be used for structural steel.

Expansion anchors and power set anchors shall not be less than 6 mm (1/4-inch) diameter and shall extend at least 50 mm (2 inches) into the masonry or concrete.

All steel hardware shall be galvanized. Hardware for stainless steel boxes and other stainless steel items shall be stainless steel.

Screws for the attachment of pole handhole covers, covers on cast metal boxes, doors on transformer bases, and other such applications shall be nylon-coated stainless steel.

**1085.09 Mounting Pad.** When mounted on bridges, a 13 mm (1/2 inch) thick vibration mounting pad shall be included with the pole. The pad shall have the same shape as the bottom of the pole base with appropriate bolt holes and opening for the center of the pole. Included with the pad shall be four 13 mm (1/2 inch) thick washers. The pad and washers shall be made from Fabreeka. The ultimate breakdown of the pad under compressive load shall be not less than 69 MPa (10,000 psi) for the specified thickness without extrusion or detrimental reduction in thickness. The material shall also have a Shore-A Durometer reading of not less than 80.

**1085.10** Anchor Bolts. Anchor bolts shall be according to ASTM A687. Nuts shall be hexagon nuts according to ASTM A 194 2H or ASTM A 563 DH, and washers shall be according to ASTM F 436.

The entire length of the anchor bolts as well as the nuts and washers shall be hot dip galvanized according to ASTM A 153. The anchor bolts shall be threaded a minimum of 150 mm (6 inches) with a minimum of 75 mm (3 inches) of threaded anchor bolt embedded in the foundation. The threaded anchor bolt extension shall be coordinated with the light pole and breakaway device requirements, as applicable.

1085.11 Reserved.

1085.12 Reserved.

1085.13 Reserved.

1085.14 Reserved.

## 1085.15 Electrical Raceway Materials.

(a) Rigid Metal Conduit. The conduit, after fabrication, shall be thoroughly cleaned and the inside and outside surfaces shall be galvanized.

Couplings and fittings shall meet ANSI Standard C 80.1 and shall be hot-dip galvanized. Elbows and nipples shall conform to the specifications for conduit. All fittings and couplings for rigid conduit shall be of the threaded type.

- (1) Rigid Steel Conduit. Rigid steel conduit shall be galvanized and manufactured according to U.L. Standard 6 and shall meet Federal Specification WWC-581, ANSI Standard C 80.1, and the requirements of NEC Article 346-15.
- (2) Intermediate Metal Conduit. Intermediate metal conduit shall be

manufactured according to U.L. Standard 1424 and shall meet Federal Specification WWC-581 and the requirements of NEC Article 345-16.

After fabrication, the conduit shall be thoroughly cleaned and the inside and outside surfaces galvanized.

Couplings and fittings shall meet ANSI Standard C-80.1 and shall be hot-dipped galvanized. All fittings and couplings for conduit shall be the threaded type.



PVC Coated Galvanized Steel Conduit. The conduit prior to coating shall be according to Article 1085.21 and be manufactured according to NEMA Standard No. RN1-1986.

The PVC coating shall have the following characteristics:

Hardness: 85+ Shore A Durometer Dielectric Strength: 400V/mil @ 60 Hz

Aging: 1,000 Hours Atlas Weatherometer
Temperature The PVC compound shall conform at

0 °F. to Federal Specifications

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Elongation: 200%

The exterior galvanized surfaces shall be coated with a primer before the PVC coating to ensure a bond between the zinc substrate and the PVC coating. The bond strength created shall be greater than the tensile strength of the plastic coating. The nominal thickness of the PVC coating shall be 1 mm (40 mils). The PVC shall pass the following bonding test:

Two parallel cuts 13 mm (1/2 inch) apart and 40 mm (1 1/2 inches) in length shall be made with a sharp knife along the longitudinal axis. A third cut shall be made perpendicular to and crossing the longitudinal cuts at one end. The knife shall then be worked under the PVC coating for 13 mm (1/2 inch) to free the coating from the metal.

Using pliers, the freed PVC tab shall be pulled with a force applied vertically and away from the conduit. The PVC tab shall tear rather than cause any additional PVC coating to separate from the substrate.

A two part urethane coating shall be applied to the interior of the conduit. The internal coating shall have a nominal thickness of 0.05 mm (2 mils). The interior coating shall be applied in a manner so there are no runs, drips, or pinholes at any point. The coating shall not peel, flake, or chip off after a cut is made in the conduit or a scratch is made in the coating. The urethane interior coating applied shall afford sufficient flexibility to permit field bending without cracking or flaking of the interior coating.

All conduit fittings and couplings shall be as specified and recommended by the conduit manufacturer. All conduit fitting covers shall be furnished with stainless steel screws which have been encapsulated with a polyester material on the head to ensure maximum corrosion protection.

#### **Electrical Materials**

- (4) Liquid Tight Flexible Metal Conduit. Liquid-tight flexible metal conduit shall be manufactured according to U.L. Standard 360. The conduit shall have a temperature range of -20 °C to +60 °C. The thermoplastic covering shall be oil resistant. Conduit from 10 mm (3/8 inch) diameter to 25 mm (1 inch) diameter shall have an integral copper ground wire embedded in the sheath. Larger diameters shall have fittings for an external bonding jumper.
- (5) Aluminum Conduit. Aluminum conduit shall be manufactured of 6063 aluminum alloy, T-1 temper, according to U.L. Standard 6 and shall meet Federal Specification WW-C-540c, ANSI Standard C-80.5 and the requirements of N.E.C. Article 346-15.
- (b) Rigid Nonmetallic Conduit.
  - (1) PVC Conduit.

The conduit, fittings, and accessories shall be manufactured from polyvinyl chloride complying with ASTM D 1784 and with all the applicable requirements of NEMA Publication No. TC2, U.L. Standard 651 for EPC-40-PVC and NEC Article 347.

Fittings and accessories for the electrical plastic conduit shall comply with all applicable requirements of NEMA Publication No. TC3.

The solvent cement used to join the conduit and fittings shall be according to ASTM D 2564.

(c) Coilable Nonmetallic Conduit.

Polyethylene Duct. The duct shall be a plastic duct which is intended for underground use and can be manufactured and coiled or reeled in continuous transportable lengths and uncoiled for further processing and/or installation without adversely affecting its properties of performance. The duct and its manufacture shall conform to the standards of NEMA Publication No. TC-7 and ASTM D 3485.

The duct shall be made of high density polyethylene which shall meet the requirements of ASTM D 1248, Type III Class C and the requirements listed in Table 2-1 of NEMA Standard Publication No. TC-7.

Duct dimensions shall conform to the standards listed in Table 2-2 of NEMA Standard Publication No. TC-7.

Performance Tests. Polyethylene Duct testing procedures and test results shall meet the requirements of NEMA Standard Publication No. TC 7 Part 3. Certified copies of the test report shall be submitted to the Engineer prior to the installation of the duct.

#### 1085.16 Expansion Fittings for Raceways.

(a) Expansion couplings for metallic raceways shall consist of a 200 mm (8 inch) expansion fitting plus a deflection fitting which allows for a 20 mm (3/4 inch) deflection. All couplings except those used indoors shall have a bonding jumper. Couplings used indoors shall be listed for use without a bonding jumper. Bonding jumpers for exposed metallic raceways shall be external. The coupling may be a combination of the 2 fittings or a single fitting assembly.

(b) Non-metallic Couplings. Expansion coupling for non-metallic raceways shall be made of PVC and consist of a 200 mm (8-inch) expansion fitting plus a deflection fitting which allows for a 20 mm (3/4 inch) deflection. The coupling may be a combination of the 2 fittings or a single fitting assembly.

**1085.17** Stainless Steel Junction Box. The box shall be made of Type 304 stainless steel, not less than 2.03 mm (14 gauge), with all seams continuously welded with stainless steel weld wire and ground smooth. Exterior surfaces shall have a smooth polished finish. The box shall be UL 50 "Junction and Pull Box", "Junction Box", or "Pull Box".

A grounding lug shall be provided for the connection of the equipment grounding conductors as required by NEC Article 250-114.

When specified for attachment to a structure, the box shall:

Conform to NEMA Type 4X.

Have an overlapping stainless steel cover and shall be secured to the box with a continuous stainless steel hinge and a minimum of 4 captive stainless steel clamps utilizing captive stainless steel hex-head bolts or deep slotted stainless steel screws.

Be suitable for surface mounting, complete with external stainless steel mounting lugs or brackets welded to the enclosure.

The box cover shall have a continuous formed, seamless, urethane, oil-resistant gasket. The gasket shall be placed directly onto the junction box cover. The gasket shall adhere to the cover without the use of adhesives. A neoprene strip gasket, or urethane strip gasket cut out of a larger sheet and glued to the junction box will not be acceptable.

When specified for embedment in structure, the box shall be constructed to NEMA 4X standards, with an oil-resistant gasket between the body and cover and with the cover arranged to fit flush with the structure surface. The cover shall be attached with stainless steel unslotted hex-head screws.

**1085.18 Composite Concrete Junction Box.** The junction box shall be constructed to NEMA 4X standards, with a closed-cell oil-resistant PE gasket between the body and cover. The cover shall be arranged to fit flush with the structure surface. The cover shall be attached with stainless steel hex-head bolts factory coated with anti-seize compound.

The box and cover shall be constructed of a polymer concrete and reinforced with a heavy-weave fiberglass cloth. The material shall have the following properties:

compressive strength, 75.8 MPa (11,000 psi) tensile strength, 11.7 MPa (1700 psi) flexural strength 51.7 MPa (7500 psi).

The resulting enclosure shall have a service load of 35.6 kN (8,000 lbs.), (minimum), over a 250 mm (10-inch) square area as defined by AASHTO H 10. The material shall have light gray color to match the surrounding concrete. The cover shall be made of the same material.

Conduit openings may be factory cut and pre-assembled with conduit fittings. Conduit fittings and accessories shall be manufactured from polyvinyl chloride complying with ASTM D 1784 and shall comply with all the applicable requirements of NEMA Publication No. TC2, U.L. Standard 651 for EPC-40-PVC and NEC Article 347.

Slight deviations to a larger size than the specified sizes may be allowed to conform to a standard manufacturer's production size with the approval of the Engineer.

**1085.19 Concrete Junction Box.** The box shall be constructed with Class SI Concrete conforming to Section 1020. The dimension and wall thickness of the box shall be as detailed on the plans.

The cover for the junction box shall be made of cast iron conforming to the requirements of AASHTO M 105, Class 30 or better, or steel. The cover for the junction box shall be designed to withstand AASHTO H-15 loading. The cover shall have a legend "IDOT LIGHTING" or "IDOT SIGNALS" when used for highway lighting or traffic signals respectively.

The cover shall be fastened to the junction box with stainless steel bolts or screws conforming to the requirements of Article 1006.31. A heavy-duty gasket shall be provided between the cover and the box for a watertight seal.

**1085.20 Cast Iron Junction Box.** The box shall be made of cast iron, hot dip galvanized, and UL-listed, NEMA 4.

When specified for attachment to structure, the box shall be suitable for surface mounting, complete with external mounting lugs integral to the casting and shall have a gasketed flange cover. Mounting lugs shall be integral with or securely attached to the box, maintaining the NEMA 4 rating and galvanizing shall be done after the lugs are attached.

When specified for embedment, the box shall be suitable for encasement in concrete with a flush gasketed cover, recessed within an outside flange frame. When embedded, the junction box does not require mounting lugs.

Covers shall be attached with hex-head unslotted silicon bronze screws. The Engineer will determine the application of screws based on the box location.

#### 1085.21 Reinforced Plastic Mortar Junction Box.

(a) The Box. The box shall be constructed with the following materials:

45 - 50 percent pea gravel

30 - 35 percent graded sand

4 - 18 percent polyester resin

2 - 3 percent fiberglass

The material shall have the following mechanical properties:

Compressive strength 75.8 MPa (11,000 psi) Tensile strength 11.7 MPa (1,700 psi) Flexural strength 51.7 MPa (7,500 psi)

The dimension and wall thickness of the box shall be as detailed on the plans.

(b) The Cover. The cover for the junction box shall be made of cast iron according to AASHTO M 105. Class 30 or better, or steel according to the requirements of Article 1006.04. The cover for the junction box shall be designed to withstand AASHTO H 20 loading. The cover shall have a legend "IDOT LIGHTING" or "IDOT SIGNALS" when used for highway lighting or traffic signals respectively.

A heavy-duty gasket shall be provided between the cover and the box for a watertight seal.

The cover shall be fastened to the junction box with stainless steel bolts or screws according to the requirements of Article 1006.31.

## 1085.22 Pulling Pedestal.

(a) Enclosure. The pulling pedestal enclosure shall be a single door design, fabricated from 3 mm (0.125 inch) thick Type 5052-H32 aluminum. The enclosure door frame shall be double flanged out on all 4 sides. All external hardware shall be stainless steel. The enclosure shall have a NEMA 3R rating. Where no dimensions are indicated on the plans, the cabinet shall be sized to adequately house all required components, cables, and fully comply with NEC pull box sizing requirements.

The door shall be constructed form the same material and thickness as the cabinet. The door shall be equipped with a 3 point latching mechanism with nylon rollers at the top and bottom. The door handle shall be stainless steel and shall have a minimum diameter of 13 mm (1/2 inch) and have a padlock provision. The door shall be sealed with a neoprene gasket. The door hinge shall be a heavy gauge continuous hinge with a 6 mm (1/4 inch) diameter stainless steel hinge pine. The hinge shall be secured with stainless steel carriage bolts and stainless steel nuts and locknuts.

Ground Lug. The enclosure shall have a ground lug suitable for installation of a 2/0 ground wire.

- (b) Terminal Strips. The enclosure shall have an equipment mounting panel made of 6 mm (1/4 inch) minimum non-asbestos inorganic nonconduction material which shall be drilled and tapped for front mounting of the equipment. The panel shall be easily installed and removed from the front of the cabinet. Terminal blocks shall be 600 v, with barrier strips between poles. The terminal blocks shall be constructed so wires can be attached without the need for terminal lugs. Terminal blocks shall be sized to accept No. 14 through No. 2/0 cables and shall be made of copper. All cable and connections shall be in front of the panel.
- (c) Finish. The cabinet shall be prepared inside and outside before painting, or as otherwise recommended by the paint manufacturer and approved by the Engineer. The cabinet shall then receive 2 sprayed coats of white polyamide epoxy primer with a corrosion inhibitor applied inside and outside to all surfaces.

The primer shall have a solid content by volume of not less than 65% + 3% and each coat shall be applied to a thickness of 75-125  $\mu$ m (3-5 mils).

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The interior and exterior, (all surfaces), shall then receive 1 final coat of silicone alkyd enamel paint. The finish paint shall be applied to a thickness of  $40-60 \mu m$  (1.5-2.5 mils).

The color of the finish paint shall meet ANSI standards No. 70 Sky Gray.

The finish shall be applied according to the paint manufacturer's recommendations. The manufacturer shall certify, in writing that the finish has been applied properly.

Submittal data submitted for approval shall address the requirement for the paint manufacturer's certification and shall include a standard, single source paint warranty by the paint manufacturer or the controller manufacturer to the Department.

1085.23 Underground Cable Marking Tape. The marker shall be a 150 mm (6-inch) wide reinforced metallic detection tape consisting of a woven reinforced polyethylene tape with a metallic core or backing. The tape shall be red with black lettering or red with silver lettering reading "CAUTION - ELECTRICAL LINE BURIED BELOW" or "CAUTION - FIBER OPTIC LINE BURIED BELOW" when over the fiber optic cable. The tape shall have a thickness of not less than 200  $\mu m$  (8.0 mils). The tape shall be according to ASTM D 882, ASTM D 1682, and ASTM D 2103.

#### 1085.24 Reserved.

#### 1085.25 Conductors.

(a) General. All cable shall be rated 600 volts. The cable shall be rated 90 °C dry and 75 °C wet and shall be suitable for installation in wet and dry locations, and shall be resistant to oils and chemicals. Any cable used for a service entrance shall have a Type USE rating.

The U.L. listing mark, cable voltage, insulation type and ratings, as well as the cable size shall all be clearly printed on the cable in a color contrasting with the insulation color.

All electric cables installed shall be color coded. Neutral wires shall be color coded white. Single phase 3-wire runs of cable shall be color code 1 black, 1 red, and 1 white; three phase 3-wire runs of cable shall be color coded 1 black, 1 red, and 1 blue. Single phase 2-wire runs shall be similarly color coded based on the applicable phase(s) and neutral. Insulated ground wires, where applicable, shall be green. Color striping of cables will not be acceptable in lieu of the specified color coding means.

Cables sized larger than No. 2 AWG shall be color coded as specified having not less than 300 mm (12 inches) of cable ends length field-taped with half-lapped color tape or by other means approved by the Engineer.

(b) Copper Conductors. Conductors shall be uncoated or coated copper.

Uncoated conductors shall be according to ASTM B3, ICEA S-68-516, NEMA No. WC-8, and UL Standard 44. Coated conductors shall be according to ASTM B 33, ASTM B 8, ICEA S-68-615, NEMA No. WC-8 and UL Standard 44.

All conductors shall be stranded. Stranding meeting ASTM B 8 (or ASTM

B 496 for conductors larger than No. 2 AWG), ICEA S-68-516, NEMA No. WC-8 and UL Standard 44. Uncoated conductors meeting ASTM B 3, ICEA S-68-516, NEMA No. WC-8 and UL Standard 44.



Aluminum Conductors. Conductors shall be aluminum according to ASTM B 230 and shall be Class B stranded according to ASTM B 231, and shall conform to the values listed in the table in Article 1085.28.

## 1085.26 Cable Insulation.

- (a) XLP Insulation.
  - (1) General. Insulation cable designated as XLP shall incorporate cross-linked polyethylene (XLP) insulation as specified and shall meet or exceed the requirements of ICEA S-66-524, NEMA Standard Publication No. WC-8, U.L. Standard 44. Minimum insulation thickness at any point shall not be less than 90% of the average insulation's thickness listed in the following tables.
  - (2) Non-Aerial. Cables sized No. 2 AWG and smaller shall be solid color coded as specified via insulation color and shall be insulated with XLP insulation over the conductor with minimum average thickness not less than as indicated in the following table:

# Insulation Thickness for Cables Smaller than No. 2 AWG

Conductor Size, AWG	Average Insulation Thickness
No. 10 and Smaller	1.1 mm (45 mils)
No. 8 through No. 2	1.5 mm (60 mils)

Cables larger than No. 2 shall be insulated by XLP insulation over the conductor with minimum average thicknesses not less than indicated in the following table:

# Insulation Thickness for Cables Larger than No. 2 AWG

Conductor Size, AWG	Average Insulation Thickness
No. 1 through No. 4/0	2 mm (80 mils)
No. 250 MCM through 500 MCM	2.4 mm (95 mils)

(3) Aerial Cable Insulation. The conductors shall have the minimum average insulation thickness indicated in the following table:

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## Aerial Electric Cable Properties

Phase Conductor		Messenger wire			
Size AWG	Stranding	Average Insulation Thickness		Minimum Size AWG	Stranding
		mm	mils		
6	7	1.1	(45)	6	6/1
4	7	1.1	(45)	4	6/1
2	7	1.5	(60)	2	6/1
1/0	19	1.5	(60)	1/0	6/1
2/0	19	1.5	(60)	2/0	6/1
3/0	19	1.5	(60)	3/0	6/1
4/0	19	1.5	(60)	4/0	6/1

(b) EPR Insulation. Cable insulation shall incorporate ethylene propylene rubber (EPR) as specified and the insulation shall meet or exceed the requirements of ICEA S-68-516, NEMA Standard Publication No. WC-8, U.L. Standard 44, as applicable.

Cables sized No. 2 AWG and smaller shall be insulated with EPR insulation over the conductor with average thickness as indicated in the first table below or may be insulated with a bonded composite insulation of EPR insulation and a chlorosulfanated polyethylene jacket with average thicknesses not less than as indicated in the second table:

## Single Material Insulation Thickness

Conductor Size, AWG	Average Insulation Thickness
No. 10 and Smaller	1.1 mm (45 mils)
No. 8 through No. 2	1.5 mm (60 mils)

## **Bonded Composite Insulation Thickness**

Conductor Size, AWG	Average EPR Thickness	Average Jacket Thickness
No. 10 and Smaller	0.8 mm (30 mils)	0.4 mm (15 mils)
No. 8	1.1 mm (45 mils)	0.4 mm (15 mils)
No. 6 through No. 2	1.1 mm (45 mils)	0.8 mm (30 mils)

Cables larger than No. 2 shall be insulated by EPR insulation over the conductor and a chlorosulfanated jacket overall, with the minimum average thicknesses as follows:

## Average EPR & Jacket Insulation Thickness for Conductors Larger than No. 2 AWG



Conductor Size, AWG	Average EPR Thickness	Average Jacket Thickness
No. 10 thru No. 4/0	0.4 mm (55 mils)	11.1 mm (45 mils)
250 MCM thru 500 MCM	1.6 mm (65 mils)	1.6 mm (65 mils)

Minimum insulation thickness at any point shall not be less than 90% of the average insulation's thickness listed in the tables in Article 1085.26.

#### 1085.27 Multi-Conductor Power Cable.

(a) General. The cable shall be an assembly of insulated power conductors, plus an insulated ground wire cabled according to U.L. 1277 with fillers and binder tape, and with a jacket overall. The cable shall be 90 °C dry and 75 °C wet. The conductors and ground conductor shall be the required insulated conductors.

All conductors in the assembly may be either coated, (thinned), or uncoated copper, except all conductors of a given cable type for the project shall be of the same type and be according to Article 1085.25.

(b) Ground Conductor. The insulated ground conductor shall correspond to the insulated conductor size as indicated in the following table:

Insulated Conductor Size, AWG	Insulated Ground Conductor Size (AWG) Min.
8	10
6	8
4	8
2 thru 2/0	6
3/0 thru 4/0	4

(c) Insulation. Each conductor shall be insulated with flame retardant ethylene-propylene rubber (EPR) insulation conforming to U.L. 44, ICEA S-68-516, which shall be heat, moisture, chemical and flame resistant. These conductors shall have an average minimum insulation thickness as indicated in the following table:

## Insulation Thickness

Conductor Size, AWG	Minimum Insulation Thickness
8 thru 2	1.1 mm (45 mils)
1 thru 4/0	1.4 mm (55 mils)

Minimum insulation thickness at any point shall be 90% of the average insulation's thickness listed in the table above.

Conductor insulation shall be color coded. Neutral conductors shall be color coded white. Three conductor cables (plus ground) for use on single phase systems shall be color coded 1 black, 1 red, and 1 white. Two conductor (plus ground) cables for use on single-phase systems shall be color coded 1 black and 1 white when used on phase-to-neutral systems, and 1 black and 1 red when used on phase-to-phase systems. Three conductor cables for use on 3-phase systems shall be color coded 1 black, 1 red, and 1 blue. Ground conductors shall be color coded green. Color coding for other cable configurations and systems shall be as directed by the Engineer. Color coding shall be made by means of impregnating the insulation with the color. The coloring process shall impregnate a color which is fade resistant. Color coding via striping, lettering, painting, or other means will not be acceptable for these systems. Each conductor shall be marked by printing in a contrasting color the size, voltage rating, type of insulation, and required U.L. information.

- (d) Overall Jacket. The cable assembly shall have chlorinated polyethylene (CPE) jacket applied over the assembly. The jacket shall meet the requirements of ICEA S-68-616, Part 4 and the sunlight resistant requirements of U.L. Standard 1277. The jacket shall be marked by means of surface ink printing indicating manufacturer, number of conductors, size, voltage rating, and required U.L. information.
- (e) Quality Control. The cable shall be manufactured and tested according to ICEA S-68-516 NEMA WC 8.

Manufacturer's information submitted for approval shall include product and other data sufficient to verify compliance with all specified requirements. The cable shall be shipped to the site in wood-lagged reels or other equivalent means as approved by the Engineer. Each reel shall be tagged.

**1085.28 Aerial Cable Assembly.** The aerial cable shall be an assembly of insulated aluminum conductors according to Section 1085.25 and 1085.26 and a steel messenger wire according to Section 1085.26. The cable assembly may have the mesenger wire intertwined with the insulated cables or lashed to the insulated cables by a factory wrap.

The assembled cable shall be suitable for installation outdoors, exposed to weather. The cable assembly shall meet the following requirements.

**1085.29 Unit Duct.** The unit duct shall be an assembly of insulated conductors which are factory pre-installed in a coilable nonmetallic conduit. The polyethylene duct shall be extruded directly over the cable at the factory in long continuous lengths. The unit duct shall be according to NEC Article 343.

#### 1085.30 Light Poles.

- (a) General.
  - (1) Wind Loading and Vibration. The detailed design and fabrication of the shaft and of the mast arms shall be such as to withstand 1.3 gust factors and 130 km/h (80 mph) AASHTO criteria for wind and vibrations, caused by the wind pressure.

There shall be no excessive vibrations in the shaft, mast arm(s) under moderate wind pressure, where damage may result to the luminaire(s) and/or its component parts, and/or mast arm(s). A dampening device,

as an integral part of the shaft, shall be installed in the shaft to alleviate such excessive vibrations. The proposed vibration dampening device shall be submitted for the Engineer's approval.

(2) Shipping. The shafts shall be shipped in bundles without any wrapping on the individual shafts or the entire bundle. Appropriate bundling materials shall be used to make a rigid, long lasting bundle capable of being handled, shipped and stored without shifting or breaking of contents.

## (b) Aluminum Poles.

(1) General. All aluminum poles shall have a satin ground finish, 100 grit or finer. All exposed surfaces of the shaft shall be of a smooth, even texture, free from marks and imperfections. Aluminum tubing shall be according to ASTM B 210M (B 210), Alloys 3003 or 60061. Tempers selected shall depend on forming practices of the pole manufacturer to satisfy the following stress requirements induced by winds.

The pole shall be designed and manufactured to withstand loadings of up to and including a 34 kg (75 lb.) luminaire having an effective projected area of 0.15 m² (1.6 sq. ft.) on a single 4.5 m (15 ft.) arm, and withstand loadings of up to and including the same luminaire on each of two 3.6 m (12 ft.) arms (twin) oriented at any angle from 45 to 180 degrees apart, meeting the criteria of AASHTO for 130 km/h (80 mph) wind loading with 167 km/h (104 mph) gusts. These loading requirements shall also include all luminaire and mast arm combinations possible for the given pole height, up to and including the limits given. Information submitted for approval shall document satisfaction of this requirement.

Anchor bolt covers shall be fastened to the base with 6 mm (1/4 inch) 20 threaded steel reinforced plastic fasteners. The fasterners shall be threaded with 6 mm (1/4 inch) 20 threaded holes for bolt covers. The anchor bolt covers shall be made from aluminum, according to ASTM B 108, S5A-F, or B 26, SG70A.

The pole shall be coordinated with all luminaires to be free of susceptibility to harmful harmonics and vibrations. The pole shall incorporate an internal vibration damper.

All hardware shall be anodized aluminum according to the ASTM B 211, 2024 T4, or 300 series stainless steel.

#### (2) Mast Arm Style.

- a. General. The indicated mounting height shall be taken from the bottom of the pole shaft base plate and shall be obtained with a nominal mast arm rise of 865 mm (34-inches) as specified.
- Mast Arm. Top members of the arms shall have raceway openings extending through the bracket. Raceway openings shall be free of burrs and rough edges that may be injurious to the wires.

Exterior surfaces of the truss arms shall be free of all

#### **Electrical Materials**

protuberances, dents, cracks, or other imperfections. The rise of the truss arm, shall be a nominal 865 mm (34 inches). The truss arm shall be made of aluminum alloy tube, round, seamless, according to ASTM B 221 and 6063 T6.

The truss arms shall be supplied with fabricated aluminum brackets welded to the arms. All welds shall be heat treated after welding. The fastening of the arms to the shaft shall be clamp type bracket with stainless steel bolts, nuts, and lockwashers.

c. Shaft. The shaft shall be made of aluminum alloy according to ASTM B 221, alloy 6063 with final temper T6. The shaft shall be spun drawn to smooth circular, tubular, seamless, tapered design.

Poles for mounting heights of 10.6 m (35 ft.) or less shall have a single piece shaft with a 200 mm (8 inch) outside bottom diameter tapering to 114 mm (4.5 inch) outside top diameter. The shafts shall be designed to accommodate loading of the mast arm configuration indicated, but the minimum design criteria shall be to accommodate loading on a single mast arm length from 1.2 m to 3 m (4 to 10 ft.) and loading on twin mast arms of length from 1.2 m to 1.8 m (4 to 6 ft.) oriented 180 degrees apart, all with a minimum wall thickness of 5.6 mm (0.219 inch). Where the indicated mast arm configuration exceeds these minimum criteria, the wall thickness shall be increased to satisfy the design loading requirements.

Poles for mounting heights greater than 10.6 m (35 ft.) but less than 14.5 m (47.5 ft.) shall have a single piece shaft with a 250 mm (10 inch) outside bottom diameter tapering to 150 mm (6 inch) outside top diameter. Poles for mounting heights of 14.5 m (47.5 ft.) shall have a 250 mm (10 inch) outside bottom diameter tapering to 150 mm (6 inch) outside top diameter. Poles for mounting heights greater than 14.5 m (47.5 ft.) but less than 19.8 m (65 ft.) shall have a 250 mm (10 inch) outside bottom diameter tapering to 150 mm (6 inch) outside top diameter.

The shafts shall be designed to accommodate loading of the mast arm configuration indicated, but the minimum design criteria shall be to accommodate loading on a single truss arm of length from 1.2 m to 4.5 m (4 to 15 ft.) and loading on twin truss arms of length from 1.2 m to 3.6 m (4 to 12 ft.) oriented 180 degrees apart, all with a minimum wall thickness of 6 mm (0.250 inch). Where the indicated mast arm configuration exceeds these minimum criteria, the wall thickness shall be increased to satisfy the design loading requirements.

The bottom portion of the shaft shall be fitted with a base. The base shall be a permanent mold casting of aluminum alloy conforming to Aluminum Association designations 356.0 or A356.0, with final temper T6 of T61. The base shall be welded to the shaft by the inert gas shielded arc method. All welds shall be free from cracks and pores. All shafts with base plates shall be heat treated after welding. The base shall be equipped with anchor bolt covers. Anchor bolt slots shall be provided in the base to accommodate the required bolt circle diameter. Poles for

mounting heights of 10.6 m (35 ft.) or less shall have 290 mm (11 1/2 inch) bolt circles and poles for mounting heights greater than 10.6 m (35 ft.) shall have 375 mm (15 inch) bolt circles. The size of the slots shall be 30 x 50 mm (1 1/4 x 2 inches) as detailed on the pole drawing.

- d. Handhole. The pole shall have an oval shaped opening in the side of the shaft. The centerline of the handhole shall be 450 mm (18 inches) from the bottom of the shaft. The handhole shall be 100 x 200 mm (4 x 8 inches) in size with the 200 mm (8 inch) dimension being situated vertically and in the same plane as any one of the sides of the base. The opening in the shaft shall be reinforced with a handhole frame situated on the inside of the shaft and welded to the shaft. A 13 mm (1/2 inch) 13 tapped hole shall be provided in the frame for attaching a mechanical grounding connector. The handhole cover shall be fastened to the frame with 6 mm (1/4 inch) 20 size steel core nylon hex-head screws and the holes for the screws shall be tapped to match the screws. The handholes shall be located such that worker's accessing the handhole shall face oncoming traffic directly.
- e. Pole Cap. Top of the shaft shall be enclosed with a removable cap. The cap shall be secured in place with 300 series stainless steel screws. The design of the cap shall be such that it shall not permit entry of water into the shaft.
- f. Grommets. Two 38 mm (1 1/2 inch) diameter openings at the top portion of the shaft, shall be made and two 31 mm (1 1/4 inch) inside diameter rubber grommets shall be provided, for wiring purposes through the top member(s) of the mast arm(s). Except where special mast arm orientations are shown, the grommet openings shall be at 90 degree angles from the position of the handhole, i.e., there shall be two (2) grommet openings for each shaft, 180 degrees apart from each other and at 90 degrees apart from the handhole.
- (3) Davit Style.
  - General. The pole shall be designed such that deflection of the pole from the vertical axis does not exceed one degree per 3 m (10 ft.) of nominal pole height as caused by the deadweight moment of the arm and design-load luminaire referenced above.

Pole deflection calculations, certified by the manufacturer, shall be submitted to the Engineer as part of the data and product information submitted for approval. The calculations shall be for all lower shaft-mast arm calculations applicable to the project.

The pole shall be coordinated with all luminaires being provided to be free of susceptibility to harmful harmonics and vibrations. The pole shall incorporate an integral vibration damper. The information submitted for approval shall address this requirement.

The combined assembly shall produce a luminaire mounting height as shown on the plans. Mounting height is defined as the distance from the tenon centerline to the bottom of the pole base.

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Each pole shall be a two-piece assembly consisting of a round lower pole shaft and a round upper short-radius davit arm. The pole-arm assembly shall be part of a coordinated system with components designed such that a common lower shaft of each pole type will accept a variety of different length davit arms. Evidence shall be submitted that the pole will provide such a system, including not only the davit arm lengths specified or indicated for this project, but other arm lengths as well. As a minimum the system shall allow configurations with the following arms for each pole height:

2.4 m (8 ft.) single 3.0 m (10 ft.) single 3.6 m (12 ft.) single 4.5 m (15 ft.) single 2.4 m (8 ft.) twin

Both the lower shaft and the upper davit arm shall be of smooth circular cross-section seamless tapered aluminum alloy, Type 6063-T6. They shall be free of dents, kinks, ripples, scratches or other defects. The outer wall shall have a satin ground finish, 100 grit or finer.

b. Upper Arm. The upper arm shall slip-fit over the lower shaft not less than 300 mm (12 inches) and the assembly shall be held in place with two stainless steel bolts with associated stainless steel nuts, flat washers and lockwashers. Each bolt shall be threaded only at its end so as to minimize the potential for damage to the pole wire (no threads on inside of pole). The flush joint shall be as shown on the contract plans.

Davit arms of various arm lengths, shall be suitable for the lower shaft, regardless of mounting height and the limitation of types.

The bend shall be carefully made so that the arm is free of kinks, wrinkles or other defects.

The upper end of the arm shall have a 60 mm (2 3/8 inch) outside diameter tenon with an extension of not less than 190 mm (7 1/2 inches) or more than 265 mm (10 1/2 inches). The tenon shall be coordinated with the luminaires being furnished for the contract so no more than 50 mm (2 inches) of the tenon between the upper end of the davit arm and the luminaire is exposed.

The davit arm shall be of the short radius type, having a centerline bending radius not greater than 1145 mm (45 inches). The bend shall produce a nominal up tilt of the arm not to exceed 5-degrees for an unloaded pole and 1.5-degrees for a loaded pole. The arm shall be corridinated with the luminaire furnished and produce a level mounting of the luminaire (up tilt not greater than 1.5 degrees) with the luminaire installed. Submittal information shall include conformation of this coordination.

The davit arm, regardless of mounting height, shall have a 150 mm (6-inch) diameter at the slip point and shall taper to a 90 mm (3 1/2 inch) diameter at the luminaire end.

Each davit arm shall have a wall thickness of not less than 4.8 mm (188 mils).

c. Lower Shaft. The shaft shall have a cast aluminum base plate according to ASTM B 108, A356 T61 for aluminum alloy, welded to the pole shaft. All welding shall be performed by the inert gas shielded arc method and all welds shall be free from cracks and pores. The base plate shall have bolt slots suitable for 25 mm (1 inch) diameter anchor bolts. Poles 10.6 m (35 ft.) or less in mounting height shall have 292 mm (11.5 inch) nominal bolt circles. Poles with mounting heights greater than 10.6 m (35 ft.) shall have 380 mm (15 inch) nominal bolt circle.

The shaft shall have a 100 x 200 mm (4 x 8 inch) handhole with rounded ends. The handhole shall be reinforced and shall have a cover of the same material as the pole held in place with tamper-resistant steel core nylon screws. The handhole shall be located such that workers accessing the handhole shall face oncoming traffic directly.

The shaft shall be equipped with a ground lug, welded inside the shaft, suitable for No. 6 and No. 4 wires, located adjacent to and accessible from the handhole.

The lower shaft for 10.6 m (35 ft.) mounting height poles or less shall have a 200 mm (8 inch) bottom diameter and shall taper to a consistent diameter of 150 mm (6 inches) at a point 7.95 m (26 ft.-1 inch) for 10.6 m (35 ft.) mounting height pole or at a point 6.43 m (21 ft.-1 inch) for 9.1 m (30 ft.) mounting height poles up from the base.

The lower shaft for light poles greater than 10.6 m (35 ft.) but less than 15.2 m (50 ft.) mounting height shall have a 250 mm (10 inch) bottom diameter and shall taper to a consistent diameter of 150 mm (6 inches) at a point 11.76 m (38 ft.-7 inches) up from the base.



The lower shaft shall have a nominal wall thickness of not less than 6.4 mm (250 mils) for light pole greater than 10.6 m (35 ft.) mounting height. Shorter mounting height light poles shall have a wall thickness of not less than 5.6 m (219 mils).

- (c) Steel Poles.
  - (1) General. The poles and hardware components shall be galvanized according to AASHTO M 111. Steel selected shall have a silicone content suitable for galvanizing.

Pole shafts for mounting heights greater than 9 m (29 ft.) but less than 10.5 m (34 ft.) shall have a 200 mm (8-inch) outside bottom diameter tapering to a 100 mm (4-inch) outside top diameter.

Pole shafts for mounting heights greater than 10.5 m (34 ft.) but less than 14.5 m (47.5 ft.) shall have a 250 mm (10-inch) outside bottom diameter tapering to a 100 mm (4-inch) outside top diameter.

Poles for mounting heights of 14.5 m (47.5 ft.) shall have a 250 mm (10 inch) outside bottom diameter tapering to 150 mm (6 inch) outside top diameter. The shafts shall be designed to accommodate loading of the mast arm configuration indicated, but the minimum design criteria shall be to accommodate loading on a single mast arm of length from 1.2 m to 4.5 m (4 to 15 ft.) and loading on twin mast arms of length from 1.2 to 3.6 m (4 to 12 ft.) oriented 180 degrees apart. Where the indicated mast arm configuration exceeds these minimum criteria, the wall thickness shall be increased to satisfy the design loading requirements.

Pole shafts for mounting heights of greater than 14.5 m (47.5 ft.) shall have a 300 mm (12-inch) outside bottom diameter tapering to a 150 mm (6-inch) outside top diameter.

## (2) Mast-Arm Style.

- a. General. General requirements of (b)(1) will apply except the pole shall be designed and manufactured to withstand loadings of up to and including a 34 kg (75 lb.) luminaire having an effective projected area of 0.19 m² (2 sq. ft.) for steel, on a single 4.5 m (15 ft.) mast arm, and shall also withstand loadings of up to and including the same luminaire on each of two 3.6 m (12 ft.) arms (twin) oriented at any angle from 45 to 180 degrees apart, meeting the criteria of AASHTO for 130 km/h (80 mph) wind loading with 167 km/h (104 mph) gusts.
- b. Shaft. The shaft shall be fabricated from not less than 3.05 mm (No. 11 gauge) steel. The steel shall be according to ASTM A 595 Grade A or B. The shaft shall be smooth circular, tubular, tapered design.
- c. Base Plate. The bottom portion of the shaft shall be fitted with a base. The base shall be welded to the shaft and be free from cracks and pores. The base shall conform to AASHTO M 183M (M 183) and shall have a minimum yield strength of 248 MPa (36,000 psi). The base shall be welded to the shaft and be free from cracks and pores. The base shall be equipped with anchor bolt covers. Anchor bolt slots shall be provided in the base to accommodate the required bolt circle diameter. The base shall have a 380 mm (15 inch) diameter bolt circle. The size of the slots shall be 32 x 50 mm (1 1/4 x 2 inches) as detailed on the pole drawing.
- Anchor Bolt Covers. The anchor bolt covers shall be according to ASTM 300 series.

### (d) Stainless Steel Poles.

- (1) General. The general requirements of (b)(3) will apply.
- (2) Mast Arm Style. The mast arm shall be made according to ASTM A 201L.

The mast arms shall be supplied with fabricated stainless steel brackets welded to the arms. The fastening of the arms to the shaft shall be clamp type bracket with stainless steel bolts, nuts and lockwashers.

All hardware shall be according to ASTM 300 series.

The mast arm, when required, shall be set at right angles to the centerline of the pavement. The leveling area of the luminaire shall be set in a plane parallel to the roadway taking into consideration the up or down grade and the super-elevation of the roadway.

- (3) Davit Style.
  - a. General. The davit arm shall be of the short radius type, having a centerline bending radius of 1140 mm (45 inches), 610 mm (24 inches) for twin davit arms. The bend shall produce a maximum up tilt of the arm of 3 degrees for an unloaded pole and 1.5-degrees for a loaded pole. The arm shall be coordinated with the luminaire furnished under the contract so as to produce a level mounting of the luminaire (up tilt not greater than 1.5 degrees) with the luminaire installed. Submittal information shall include conformation of this coordination.

Each pole shall be a three-piece assembly consisting of a rectangular pole base, polysided lower pole shaft and a round upper short-radius davit arm. The pole-arm assembly shall be part of a coordinated system with components designed such that a common pole base, lower shaft assembly of each pole type will accept a variety of different-length davit arms. Evidence shall be submitted that the pole will provide such a system, including not only the davit arm lengths specified or indicated for this project, but other arm lengths as well. As a minimum the system shall allow configurations with the following arms for each pole height:

2.4 m - (8 ft.) single arm 3.0 m - (10 ft.) single arm 2.4 m - (8 ft.) twin arm

The base plate, lower shaft and the upper davit arm shall be of smooth circular cross-section. The components shall be fabricated from high strength Type 201 stainless steel, with a minimum yield strength of 414 MPa (60,000 psi) and 689 MPa (100,000) minimum tensile strength after fabrication. The longitudinal weld shall have a minimum 60% weld penetration. The components shall be free of dents, kinks, ripples, scratches, or other defects. The outer surfaces shall have a satin finish.

b. Upper Arm. The davit arm shall slip-fit over the pole shaft not less than 150 mm (6 inches) and the assembly shall be held in place with two stainless steel set screws.

The davit arm shall have a 90 mm (3 1/2 inch) inner diameter at the slip point and a 50 mm (2 inch) outer diameter at the luminaire end.

Each davit arm shall have a minimum wall thickness of 2.8 mm (109 mils).

 Lower Shaft. The base and base plate shall be fabricated from Type 201 stainless steel.



The base shall be a tapered design with a rectangular base plate with a maximum 225 mm (9 inch) width to accommodate six anchor bolts. The base shall securely slip fit into the lower shaft with a 225 mm (15 inch) overlap. The tapered base shall conceal the anchor bolts.

The base shall include a 175 x 280 x 355 mm (7 x 11 x 14 inch) flush mounted reinforced access door secured with stainless steel hardware.

The base shall be equipped with a 13 mm (1/2 inch) thirteen tapped hole for connection of the mechanical grounding connector.

The shaft shall be fabricated from high strength Type 201 stainless steel, with a minimum yield strength of 414 MPa (60,000 psi) and 689 MPa (100,000 psi) minimum tensile strength after fabrication. The longitudinal weld shall have a minimum 60% weld penetration. Minimum wall thickness shall be 2.8 mm (109 mils).

# (e) Weathering Steel Poles.

The pole shall consist of a tapered shaft, anchor bolts, nuts, bolts, washers, and incidentals necessary to complete the assembly and shall include a base plate, anchor bolt covers, pole cap, handhole and cover. Each pole shall bear a name plate or other type of indelible marking or brand that shall identify it as to type, catalog number, and manufacturer.

The pole shall be designed and manufactured to withstand a luminaire effective projected area (EPA) of 0.26 m<sup>2</sup> (2.8 sq. ft.) and maximum weight of 27.2 kg (60 lbs.) and designed to accommodate one tenon mounted luminaire for signal units and two tenon mounted luminaires on a tenon mounted bracket for the twin units.

The pole shall be fabricated from high strength, low alloy steel according to ASTM A 595, Grade C, or A 606, Type IV, minimum yeild 345 MPa and 483 MPa (50,000 psi and 70,000 psi) respectively. The base shall be fabricated, cast, or forged according to ASTM A 588. The handhole rim shall be fabricated of ASTM A 714, standard black pipe welded in a hole cut in the pole shaft. Handhole cover shall be made from 12 gauge minimum, weathering steel. The handhole shall have a clear opening not less than 117 x 178 mm (4.63 x 7 inch). Brackets for twin units shall be fabricated from 50 mm (2 inch) schedule 40 pipe 208 MPa (30,000 psi) minimum yield strength, painted with a prime coat of corrosion inhibiting polyamide epoxy and a finish coat of aliphatic acrylic polyurethane of a color to match aged weathering steel.

All shafts shall have a circular or multi-sided cross section as indicated on the plans. The centerline alignment shall not vary from base to pole top by more than 6 mm per 3 m (1/4 inch per 10 ft.) of pole height, but not to exceed 0.1 percent of the pole height.

The pole's outside surface and base plate shall be blasted according to Steel Structures Painting Council - SP6 (commercial blast) and cleaned at the factory to remove all surface contamination. The surface area shall be

free of any oil and other foreign elements. All weld spatter shall be removed, and the surface shall be an even texture, free from marks, burrs, sharp edges, or imperfections.

Each pole shall be supplied with a lug on the shaft for grounding purposes. The anchor bolt nut covers may be made of steel, malleable iron or ferrous alloy. The handhole cover and nut covers shall be secured with hexagonal head stainless steel screws.

Anchor bolts shall be the size indicated on the plans. Anchor bolts shall be furnished with nuts and washers to provide for an adequate bearing surface. The pole shall be fastened with a nut, lock, and flat washers, poles shall be provided with breakaway support couplings of the type indicated in Article 1085.36.

# (f) Wood Poles.

Wood poles shall be preservative-treated according to the American Wood Preservation Standard C4 and designated per Standard M6. Wood poles shall be fabricated according to the ANSI 05.1. Poles shall be marked or have other documentation to confirm compliance with this requirement as well as the class designation.

Poles shall also be subject to the following requirement of ANSI 05.1: Poles will not be acceptable if they contain indentations attributed to loading or handling slings that are 6 mm (1/4 inch) or more deep over 20% or more of the pole circumference, or more than 13 mm (1/2 inch) deep at any point. Other indentations or abrasions, for example, forklift damage, chain-saw damage etc., shall not be more than 1/10 the pole diameter at the point of damage up to a maximum 25 mm (1 inch). Such damage will be permitted in an oversized section, where the excess of wood will be taken into consideration in evaluating the effects of the damage. In any case, the circumference for a given class will still be required to be not less than the specification minimum.

**1085.31 Light Pole Foundation, Metal.** Metal foundations shall be fabricated from material new and unused in any previous application. The manufacturer shall provide a certification that the materials are new and meet the specified requirements and shall accompany the submittal.

Metal foundations shall be fabricated from steel.

Baseplate: AASHTO M 183 Shaft: ASTM A 252, Grade 2

(Phosphorous 0.04% maximum)

Helix Screw: AASHTO M 183
Pilot Point: AASHTO M 183

Metal foundations shall be fabricated with 2 wiring entry slots parallel with the shaft axis and aligned with base plate faces 180 degrees apart. Each slot shall have rounded smooth edges, shall be approximately 75 mm (3 inches) wide and 686 mm (27 inches) long and shall extend down from a point on the shaft 225 mm (9 inches) below the base plate. Continuous slots up and through the base plate will not be acceptable.

Foundation shaft diameters, baseplate size, shaft length and bolt circles shall be

as detailed on the plans. Foundations shall be fully coordinated with specified poles.

Studs or rods shall be 24 mm (1-inch) diameter and shall be according to AASHTO M 314. Nuts shall be hexagon nuts according to AASHTO M 291M (M 291) and washers shall be according to AASHTO M 293. Studs or rods, nuts and washers shall be hot dip galvanized according to AASHTO M 232.

## 1085.32 Light Tower.

(a) General. Light towers (high mast poles) shall consist of any poles 24 m (80 ft.) or more in length.

Each light tower shall be complete with internal, integral motorized lowering mechanism, luminaire ring, pole top hood, internal electric power cables, luminaire counter-weights, and all appurtenances required for a complete operating unit.

The design shall be based upon a wind velocity of 128 km/h (80 mph) with a 1.3 gust factor and luminaires each 39 kg (85 lbs.) and having a projected area of 0.3 m<sup>2</sup> (3.4 sq. ft.). The design shall be based upon the number of luminaire positions indicated, assuming a luminaire in each position.

Light towers shall be designed and constructed so no structural member or other component is applied in excess of the manufacturer's recommended rating (when applicable) or the published rating, whichever is lower.

The design of the tower shaft shall achieve a maximum, fully loaded deflection at the top of the pole, which is not greater than the following percentage of the tower height:

Light Tower Maximum Deflection

Tower Height in Meters	Max Deflection % of Height	Tower Height in Meters	Max. Deflection % of Height
49	13.70	33	7.80
46	10.04	30	5.30
43	7.80	27	4.50
40	6.02	24	3.50
36	10.75		

Tower Height in Feet	Max Deflection % of Height	Tower Height in Feet	Max. Deflection % of Height
160	13.70	110	7.80
150	10.04	100	5.30
140	7.80	90	4.50
130	6.02	80	3.50
120	10.75		

The light towers shall be of a height and luminaire capacity as indicated and be of the non-latching ring support design.

The tower manufacturer shall warrant the entire coordinated assembly and shall be the manufacturer of either the tower shaft or the lowering mechanism.

(b) Shaft. The tower shaft shall be a low deflection tapered shaft having poly-sided, circular, or elliptical cross sections. The shaft cross section at the top shall be not less than 190 mm (7.5 inches). The shaft cross section at the bottom shall not be greater than that which is compatible with the base plate bolt circle specified, and shall not be less than 600 mm (24 inches).

All tower shaft components, including, but not limited to the shaft sections, tower sections, base plates, handhole door, handhole reinforcing, rain gutter, and base plate, shall be fabricated from high-strength, low alloy, steel with a minimum yield strength of 345 MPa (50,000 psi) according to AASHTO M 222M (M 222), ASTM A 595, Grade A or B; ASTM 607, Grade 50; ASTM A 715, Grade 50; ASTM A 808M (A 808), or AASHTO M 223M (M 223), Grades 50 and 65.

Each tower shaft shall be constructed of not more than the following welded or slip-fitted sections:

Tower Height in Meters	Maximum Number of Sections
36,40,43,46,49	4
24,27,30,33	3

Tower Height in Feet	Maximum Number of Sections
120,130,140,150,160	4
80,90,100,110	3

Sections which are slip-fitted shall have slip joints with a minimum overlap of 1.5 times the diameter of the bottom of the upper section at the slip joint. Towers having slip joint construction shall be prefitted and match marked at the factory and shall be shipped disassembled for assembly at the jobsite.

Each tower shaft shall be constructed with a handhole/access door for access to power connections and lowering mechanism equipment. The handhole shall be large enough to make the entire lowering mechanism assembly visible from an extended operating position and accessible for maintenance. The handhole shall be sized and arranged to permit removal of the lowering mechanism without excessive dismantling of the equipment. The handhole may be a reinforced opening in the pole shaft as detailed on the plans or may be a part of a flared shaft base assembly as approved by the Engineer. The flared base shall not be considered a separate section of the tower shaft.

The handholes in the pole shafts shall have rounded corners and shall be reinforced to maintain the original strength of the tower shaft. Flared base assemblies shall maintain the strength of the shaft and have no nonround protrusions.

The handhole shall have a door with a full-height stainless steel piano hinge, or with not less than 2 stainless steel hinges, or with other hinge arrangement acceptable to the Engineer. A bolt through a door and frame eyelet shall not constitute an acceptable hinge. Hinges shall be heavy duty, suitable for the weight of the handhole door. The door/opening shall be gasketed in a manner which will prevent the entry of water into the pole and the door shall have a tight compressive seal employing a tubular gasket to assure compressibility. The door shall be held closed with a 12 gauge captive adjustable, spring loaded, stainless steel clamp assembly. The clamp assembly shall be held closed with deep slot stainless steel screws. The clamps shall have a depth stop feature to insure uniform sealing pressure at all clamp points. A minimum of 5 clamps shall be used around the nonhinged sides of the door assembly. A stainless steel padlock hasp and staple shall be provided for locking the door. Door hardware shall be stainless steel. The door shall be equipped with an integral door stop mechanism.

A rain shield shall be placed above the handhole to direct water away from the handhole. The shield shall be fabricated of the same material as the pole shaft, shall have rounded corners, and shall be permanently welded to the shaft. Details of the configuration and welding shall be submitted for the Engineer's approval.

Each tower shaft shall have a handhole-accessible ground lug welded to the shaft for connection of ground conductors. The lug shall be accessible with the lowering device installed.

Each shaft shall have ladder clips. Clips shall begin 1.8 m (6 ft.) above the base plate with alternate 900 mm (36 inch) and 250 mm (10 inch) spacing thereafter, for the entire length. The top 3 m (10 ft.) of the pole shaft shall have 3 sets of clips. Each set of clips shall be 120 degrees apart. Clips shall be 6 x 50 mm (0.25 x 2 inches) corrosion resistant steel, welded to the shaft to produce a slot 15.9 mm (0.625 inches) deep and 41.3 mm (1.625 inches) long. The top inside edge shall be chamfered.

The top of the shaft shall have a ground lug welded to the tower shaft suitable for a bolted ground connection for a lightning rod.

The base plate shall be factory pre-drilled (slotted) for the number and configuration of anchor rods as provided in the following table:

## Baseplate Configuration

Tower Height in Meters	Minimum Number of Anchor Rods	Rod Circle (mm)
40,43,46,49	8	711-914
27,30,33,36	8	711-760
24	6	711-760

Tower Height in Feet	Minimum Number of Anchor Rods	Rod Circle (Inches)
130,140,150,160	8	28-36
90,100,110,120	8	28-30
80	6	28-30

The base plate shall have a round (disk) shape of the specified outer diameter or as otherwise approved by the Engineer. The minimum thickness of the base plate shall be 50 mm (2.0 inches).

The base plate shall be circumferentially welded to the tower shaft.

All tower shaft hardware, such as hardware for the handhole door, including the handle/latch mechanism, hinge and door stop, shall be stainless steel.

## (c) Welding.

 Requirements. Circumferential welds, including top flange welds, shall be full penetration welds.

Longitudinal welds shall have a minimum of 75% penetration, except the longitudinal welds on both the male and female shaft sections shall be full penetration welds within a distance of 2 diameters of overlap ioints.

Minimum preheats for welds shall be 40 °C (100 °F.) for fillets, 65 °C (150 °F.) for seams, and 110 °C (225 °F.) for circumferential welds.

Weld procedure specifications for seams and circumferential welds must be qualified according to Section 4, Part B of AWS D1.1. Charpy V-Notch (CVN) impact specimens shall be tested according to Table III-1 (note 2) of Appendix III for minimum values of 34 J (25 ft. lbs.) at 4 °C (40 °F.). Fillet weld procedures shall be tested according to Table 4.4 of AWS D1.1.



The welds shall be smooth and thoroughly cleaned of flux and spatter.

All full penetration welds shall be inspected for soundness by the radiographic and/or ultrasonic methods and all partial penetration welds shall be inspected by the magnetic particle method. Welding inspection reports shall be submitted to the Engineer for approval. The welding symbols and complete information regarding location, type, size, welding sequence, and WPSs shall be shown on all shop drawings. The Contractor shall submit the manufacturer's welding procedures to the Engineer for approval.

(2) Inspection. In addition to manufacturer's own welding inspection, the Contractor shall have welding inspected by an independent Certified Welding Inspector (CWI). The selected inspector shall be approved by the Engineer before any inspecting is performed. The NDE inspector(s) shall be independent nondestructive testing inspector(s), certified as level II in RT, UT, and/or MT as applicable.

The methods for testing full penetration and partial penetration welds

by the independent welding inspector(s) shall be the same as specified above.

The independent welding inspector shall send the test results directly to the Engineers, as follows: Illinois Department of Transportation, Attn: Engineer of Structural Services, 2300 S. Dirksen Parkway, Bureau of Bridges & Structures, Springfield, Illinois 62764 and to the applicable District Engineer.

(d) Light Tower Finish. The entire tower shall have a painted finish, the outside and the inside of the light tower shaft including the handhole, handhole door, base plate, and all other elements welded to the shaft, as well as the fixed structural components and outer cover of the lowering device shall be painted with 2 coats of different colored primer and 1 coat of finish paint. The finish paint shall be applied on the outside surfaces only. Stainless steel, mechanical or electrical components shall not be painted.

When specified only the bottom 3 m (10 ft.) of each pole base, inside and out, and the tower section slip joint surfaces shall be painted with 2 coats of different colored primer paint and 2 coats of finish paint.

The surfaces of the poles to be painted shall be prepared according to the Steel Structures Painting Council, SSPC-SP-10 near white blast cleaning specifications to a surface profile of 25 to 75  $\mu m$  (1-3 mils). Surface areas shall be free of any weld splatter, oil, grease, or other foreign matter.

The primer and the finish paint shall be as specified in the contract. The color shall be Federal Standard Color Number 6307, (Hanford Gray).

Before the painted surfaces are accepted, the Contractor shall furnish to the Engineer, the paint manufacturer's normal warranty and certification that the paint has been properly applied. The paint shall be applied under the paint manufacturer's supervision, indoors, under proper temperature and humidity conditions.

(e) Head Frame. Each tower shall be equipped with a head frame assembly to support and guide the luminaire ring assembly. The head frame and luminaire ring shall have a positive mating/alignment interface at which the seating force is applied at each support cable. The interface shall be designed to operate with not less than 1.3 kN (300 lbs.) of total seating force distributed among the interface points.

All head frame members and components, including support arms, shall be fabricated of steel of the same type as specified for the tower shafts or stainless steel of appropriate strength.

The head frame shall have a head plate, a support, and 2 pulleys for each support cable.

The head frame shall have a power cable pulley placed between and roughly equidistant from 2 support arms, with a pulley diameter around the groove of not less than 350 mm (14 inches).

Pulleys shall be constructed to allow associated cables to ride freely within pulley grooves and cable guides shall be incorporated to prevent cables from riding out of pulleys.

Pulleys, attachment hardware, latches, hinges and the like shall be stainless steel. Pulleys shall be made of Unified Numbering System type 300 stainless steel and have permanently lubricated sealed bearings except the power cable pulleys may be cast aluminum or high-strength nylon.

The head frame assembly shall be equipped with a metal hood. The hood shall protect the operating head frame components from damage or deterioration from weather but shall permit pole ventilation while preventing the entry of birds. The hood shall have a strong secure mechanical means to open/raise the hood for the future maintenance of the head frame and shall have a double-secured latching system to assure closure.

The head frame assembly shall be match-marked to its tower shaft and shall be attached to the shaft by stainless steel hardware.

(f) Luminaire Ring. Each tower shall be provided with a luminaire ring suitable for the quantity, type, and orientation of the luminaires specified. The ring shall mate/align with the head frame and shall be coordinated relative to seating force.

The ring shall be designed for lowering to a position with the center line of luminaire arms 1.4 m (54 inches) or less above the top of the tower base plate. The exact fully-lowered position shall be adjustable in the field. Wiring shall be fully enclosed in metal raceway.

The ring shall be equipped with bumpers, rollers, or other shock-absorbing mechanism to guide the ring during the raising/lowering operations. The guide mechanism shall be spring loaded or shall otherwise be designed to minimize shock to the luminaire during raising and lowering.

Arms for the attachment of luminaires shall be standard 50 mm (2-inch) diameter tenon arms. The arms shall be attached to the ring in a secure manner either by welding or by means of stainless steel bolts, nuts, lockwashers and hardware such that a permanent rigid attachment is achieved. Arms shall be approximately 325 mm (13 inches) in length, coordinated with luminaire size and configuration and shall be arranged so that the overall diameter of the ring, including the luminaire, does not exceed 3.4 m (11 ft.).

The ring shall be equipped with an enclosed wire raceway and a stainless steel terminal box built according to NEMA 4 requirements for wiring of the luminaires. The box shall be equipped with a hinged door and a latch or with captive stainless steel closure hardware acceptable to the Engineer and an external special fixed-mount plug with a retained cap as specified elsewhere herein to accept a test power connection when the ring is in the lowered position.

The box shall contain a terminal strip with identified terminals for connection of the main power cord, luminaires, and the test power receptacle. The terminal strip shall have terminals sized to accommodate the cables to be connected and shall have luminaire connection terminals to accommodate the usage of all luminaire positions. The ring shall facilitate ease of wiring to the arms by the use of removeable gasketed covers, physical arrangement, or other means acceptable to the Engineer. Arms shall be factory or field wired according to NEC Article 410-31 using No. 10 wire having ethylene propylene rubber (EPR) insulation or bonded composite

EPR insulation with a chlorosulfanated polyethylene jacket, rated 600 V not less than 90 °C ( °F.), RHH-RHW, U.L. listed with solid color coding. Wiring shall be color coded (black, red, white, and green, as applicable) with coloring via outer material color or by painting with a process approved by the Engineer. Wire rating information shall be visible in a contrasting color. Wires shall be installed to all luminaire arms. Luminaire wires shall extend 600 mm (24 inches) longer than their respective tenon arm and shall be trained back into the arm which shall then be closed with a protective cap for shipment of the jobsite. Unused wires shall be capped and crimped with insulating sleeves. All ring wires shall be tagged with wire markers at both ends. The tenon arms shall also be tagged corresponding to the wiring contained within.

The luminaire ring shall be factory checked and marked for proper positioning and luminaire orientation. Catalog cuts and shop drawings shall indicate the orientation of the luminaire ring, handhole, and bolt circle in relation to each other on a single drawing.

The ring shall be complete with a counterweight for each unused luminaire position plus one additional counterweight. Counterweights shall be based upon the luminaires to be installed on each respective tower.

All luminaire rings shall be arranged to accommodate the complete indicated compliment luminaires, regardless of the number actually to be installed, to facilitate luminaire positioning and orientation. For rings of 6 positions or less, each position shall have a tenon arm. For rings of more than 6 luminaire positions, the arrangement shall be accomplished by a "T" type of tenon arm to produce two luminaire mounting positions from a single extension arm, or by other means approved by the Engineer.

(g) Lowering and Support Mechanism. The support shall be of the non-latching design.

The mechanism shall operate to raise the luminaire ring to its fully raised position and to lower the ring to a position with the centerline of the luminaire tenon arms 1.4 m (54 inches) or less above the top of the tower base plate. The exact fully-lowered position shall be adjustable in the field.

The lowering and support mechanism shall include, but not be limited to the support cables, power cable, pulleys, winch, gear reducer, mechanical clutch, electric motor, control and all accessories and appurtenances for a coordinated operating system.

The lowering and support scheme shall be of the 2-cable or 3-cable type as specified.

Three-cable mechanisms shall incorporate 3 support cables joined via an appropriate proven transition design to a single hoist cable wound around a single hoist winch. The transition design shall be such to prevent twisting of the support cables, to assure smooth winding of the cables on the winch and to prevent binding on the inside of the tower shaft.

Two-cable mechanisms shall incorporate 2 support/hoist cables wound around a dual winch assembly. The design shall be such to prevent twisting of the cables and to assure smooth winding of the cables on their respective winches and to prevent binding on the inside of the tower shaft.

The hoisting system shall be securely mounted and the lower assembly, i.e. motor, winch, mechanical clutch, gear reducer, etc., shall be designed to allow ease in removal of the equipment via the tower handhole without dismantling the system. Individual components shall be accessible and removable without the removal of other components.

The device shall tightly position the luminaire mounting ring against the head assembly frame by applying a holding force of 1.3 kN (300 lbs.) minimum, to be distributed among the seating/interfacepoints. The total force required by the system must not be less than 1.3 kN (300 lbs.) greater than the weight of the luminaire mounting ring with luminaires. There shall be a positive indication at the handhole that the required force has been applied, visible from the extended operating position away from the handhole and not under the ring.

The mechanism shall be equipped with a multi-point safety chain and hook assembly to maintain the tension on the support system, allowing the motorized winch assembly to be disengaged. Chain and all hardware shall be stainless steel.

The system shall be designed so that unbroken power cable, suspension and/or hoist cable can be replaced from ground level.

(1) Support and Hoist Cables. Cables (wire rope) shall be manufactured from Type 302 stainless steel having a carbon content of 0.09 to 0.15 and shall be a stranded assembly coated with a friction-limiting non-corrosive lubricant.

Cables shall be 7x19 wire strand and have no strand joints or strand splices.

Cables shall be manufactured and listed for compliance with military specification MIL-W-83420B, Type 1, Composition B.

Cable terminals shall be stainless steel compatible with the cable and as recommended by the cable manufacturer. The terminals, swaging, etc. shall meet the requirements of military specification MIL-T-781 and shall be so listed.

For 3-cable systems, the support cables shall each be not less than 5 mm (3/16 inch) in diameter and the hoist cable shall not be less than 8 mm (5/16 inch) in diameter.

For 2-cable systems, the support/hoist cables shall each be not less than 6 mm (1/4 inch) in diameter.

As part of the tower shop drawings and product data submitted for approval, support and hoist cable information shall be provided. Submittals without such information will be incomplete and will be rejected.

The information shall include, but not limited to:

 Catalog information to confirm sizing, stranding and other specified requirements.

- b. Evidence of listing as military specification cable as specified.
- Certification of compliance with all specification requirements made by the cable manufacturer.
- d. Documentation of arrangement to provide a sample of the support cable to an independent laboratory as selected by the Engineer for testing to the military specifications listed herein, with results to be sent directly to the Engineer, all included incidental to this item.
- e. Copies of recent test reports made on identical cable indicating compliance with military specification requirements. The test reports shall include as a minimum, the following:
  - 1. Breaking Strength test.
  - 2. Endurance test.
  - Stretch test.
  - Test load.
  - Chemical Composition.

## (2) Winch.

- a. Drum. The winch/gear reducer assembly shall have a drum suitable for the hoist of support/hoist cables, arranged to provide smooth winding of the cable and to prevent slippage. The drum shall be stainless steel or cast/ductile iron and shall have a diameter not less than 18 times the diameter of its respective cable (wire rope). The drum shall have the end of the cable attached by means of a swagged connection and one full layer of cable shall be wound on the drum even when the ring is in the fully lowered position. The drum flange axle shall be supported at both ends.
- b. Gear Reducer. Each assembly shall incorporate a gear reducer having a reduction ratio which will prevent free fall of the located luminaire ring upon failure or disengagement of the drive unit and which will produce a travel rate of 3 m (10 ft.) to 4.6 m (15 ft.) per minute under normal operation.

The unit shall have a worm gear which is totally enclosed in a lubricating reservoir. The lubricant shall have a viscosity range suitable for proper operation in ambient temperatures from -40 °C to 49 °C (-40 °F. to 120 °F.)

The worm shall be manufactured of case hardened ground alloy steel or cast iron.

The gear shall be of bronze alloy or of a proven alternate material and design acceptable to the Engineer with and the gear shall be keyed to the output shaft.

The output shaft shall be high quality medium carbon steel ground to close tolerances. The worm and output shaft shall be

mounted on anti-friction bearings.

All shaft extensions shall be equipped with a lip-type synthetic element and oil seals.

The unit shall have provisions to verify oil levels in all gear boxes.

- c. Clutch. The mechanism shall incorporate a mechanical clutch, installed between the winch/gear reducer and the cable winch assembly. The clutch shall be of mechanical type, in a sealed cast metal housing. The clutch torque shall be factory calibrated and coordinated with the electric motor. The clutch shall act to limit the seating force of the raised ring to a pre-established value. The clutch shall be suitable for the application and torque limitation and shall not deteriorate with use.
- d. Motor. The electric motor shall be matched to the load and torque characteristics required for a fully loaded luminaire ring and shall not be less than 746 watts (1 horsepower).

The motor shall be capable of producing torque in excess of the clutch maximum torque rating.

The motor shall be totally enclosed fan cooled (TEFC), shall be reversible to operate the lowering mechanism in both directions, and shall be suitable for operation on the power supply characteristics shown on the drawings.

Submittal information shall include complete motor data, including, but not limited to:

- 1. Manufacturer
- 2. Nameplate Rated Watts (Horsepower)
- 3. Rated Voltage
- 4. Full Load RPM
- 5. Full Load Current
- 6. Locked Rotor Current
- 7. NEMA Design Letter
- Insulation Class
- 9. Torque Data
- 10. Dimensional Data
- (3) Lowering Device Control. The lowering device control shall consist of motor short circuit and motor running overcurrent protection and motor control complete with all appurtenances and interconnecting wiring. The control may incorporate a reversing motor starter or a suitably-rated reversing control station.

The lowering device control may be provided in a separate NEMA 4 stainless steel enclosure or in the enclosure with the tower main

breaker, provided the remote control station is a separate remote device.

The lowering device motor shall have a motor disconnecting means circuit and running overload protection according to NEC requirements. The motor disconnect and short circuit protection shall be achieved by a molded case thermal magnetic bolt-on circuit breaker rated at 600 volts, of an ampere rating suitable for the motor and having a UL-listed interrupting rating of not less than 14,000 rms symmetrical amperes at 480 volts and 10,000 rms symmetrical amperes at 240 volts. Running overcurrent protection shall be according to N.E.C. requirements. Motor overload protection shall be achieved by an appropriate dual element fuse in a spring-loaded screw-in type small-dimension fuse holder mounted within the enclosure in a suitable box or other arrangement approved by the Engineer.

The motor starter, if incorporated, shall not be smaller than NEMA size 1, shall be rated 600 volts and shall be full voltage, 2-pole reversing type, with arc-extinguishing characteristics and renewable silver-to-silver contacts. A reversing control switch, if incorporated, shall be rated well in excess of the duty required and in no case less than 2,240 watts (3 horsepower) at 230 volts single phase. The control shall be momentary contact, up-stop-down, requiring positive action by the person operating the device to keep the motor energized. The control shall have auxiliary contacts as indicated and as required for the control.

The enclosure shall have an exterior position indicating trip-free operating handle for the motor circuit breaker. The enclosure shall have exterior nameplates to read "LOWERING DEVICE CONTROL" and "MOTOR CIRCUIT BREAKER" as well as an interior nameplate "MOTOR OVERLOAD FUSE" which shall also be inscribed with the applicable fuse type and ratings. Nameplates shall be engraved, 2-color, attached with screws.

The line side power to the lowering device control shall be obtained via a plug extended connection to the power distribution cord/receptacle.

The control shall be complete with a cable-connected remote control station. The control station shall incorporate heavy duty control devices in a non-metallic impact-resistant NEMA 4 enclosure. The control shall be "dead man" type with "RAISE" and "LOWER" controls, requiring the operator to hold the respective control depressed for movement of the ring in either direction and with release of the control to stop the mechanism. The cord shall incorporate a No. 12 ground wire and the number of conductors required for a control, with control conductors not less than No. 14. The cord shall be weatherproof with watertight connections at either end and it shall be long enough to allow the operator to stand 7.5 m (25 ft.) away from the lowered luminaire ring. Provisions for storage of the control station and cord shall be provided in a manner easily accessible at the handhole and in a location which precludes interference with the internal components of the lowering mechanism.

Cables extended from the enclosure shall be passed through a watertight sealing bushing and the cable shall be supported and arranged to preclude interference with the lowering mechanism.

Wiring shall be in compliance with NEC requirements. Motor wires shall not be less than No. 12 and motor wiring shall be extended in UL-listed extra-flexible, weatherproof cord or other cord approved by the Engineer with suitable fittings, bushings and supports. All equipment shall be grounded via an appropriately sized equipment ground wire.

(4) Electric Power Distribution. Electric power for motorized operation of the lowering mechanism and for the power supply to the lighting shall be taken from the lighting circuitry feeding the tower. The distribution shall provide termination of the supply feeder, extension to a tower main breaker and distribution to lighting and the lowering device.

The power feeder supplying the tower shall terminate in standard-type fuseholder. The fuseholders shall be single-pole, rated 60 A and shall be fused to an ampacity not greater than the tower Electric Power Cable specified herein. Fusing shall be extended to the tower main breaker by multi-conductor tower. Electric Power Cable as specified, with the fuse end fitted with a heat-shrink multi-leg boot. The end of the cable shall be wrapped with sealant tape recommended by the boot manufacturer around and between individual insulated conductors, with the boot overall. The boot shall meet military specification MIL-I-81765/1.

The tower shall be equipped with a main circuit breaker. The circuit breaker shall be molded case, 2-pole, 40-ampere thermal magnetic, bolt-on type having a UL-listed interrupting rating of not less than 14,000 rms symmetrical amperes at 480 volts. The breaker shall indicate "ON", "OFF" and "TRIPPED" conditions and the handle shall be trip-free.

The main breaker shall be housed in NEMA 4 stainless steel enclosure with an external, position-indicating operating handle with padlock provisions. The enclosure shall have a 2-color engraved nameplate to read "MAIN BREAKER", attached with screws.

The load side of the main breaker shall be connected to a cord and receptacle which shall be arranged for connection to either the luminaire ring main power, the lowered luminaire ring test power or the lowering device control.

Each connection to the main breaker shall be made with the specified electric power cable, extended from the enclosure through a watertight sealing/support bushing. The cables shall be arranged and secured to preclude any interference with the lowering device operation.

(5) Electric Power Cable. The electric power cable shall consist of a 4-conductor jacketed extra flexible cable, (2 phase conductors, neutral conductor and a ground conductor) Type W industrial grade portable power cable, as listed in NEC Table 400-4. The cable shall meet ICEA S-68-516, WC-3 and shall be approved by the Pennsylvania Bureau of Mines.

Each conductor shall be stranded assembly of 133 flexible annealed copper wires according to ASTM B 33. Each of the 4 conductors shall be sized No. 6.

Each conductor shall be individually insulated with ethylene propylene rubber insulation, all in compliance with ICEA S-68-516. Insulation shall be rated not less than 600/2000 volts, 90 °C (194 °F.) and insulation thickness shall not be less than 1.5 mm (60 mils).

Each individual conductor's insulation shall be color coded; one black, one red, one white and one green.

The individual conductors shall be assembled in a cable, with non-hydroscopic reinforced rubber fillers to maintain a smooth round outer surface, with a jacket applied overall. The jacket shall be a heavy duty jacket manufactured according to ASTM D 752 and shall be imprinted with the manufacturer, conductor size number of conductors, type of cable, voltage rating, and Pennsylvania Bureau of Mines designation P-XXX-MSHA.

(h) Lightning Protection. A copper clad steel lightening rod 13 mm (1/2 inch) in diameter X 900 mm (36 inches) long shall be attached to the head of the frame.

A flexible copper braid connector of 100A minimum capacity shall be installed between the lightning rod and grounding lug on the top of the tower shaft. Good metal-to-metal contact shall be assured by bolted connections using lugs and connectors specifically approved for the purpose.

Similar copper braid shall be attached with studs and exothermic welds at tower shaft sections or the shafts shall be electrically joined by other means approved by the Engineer.

A stranded bare soft copper wire shall be attached between ground rock at the foundation and a ground lug in the tower shaft at the handhole. The copper ground wire shall be exothermically welded to the ground rod.

(i) Ladder Set. Ladder sets shall be designed and constructed such that no structural member or other component is applied in excess of the manufacturer's recommended rating (when applicable) or the published rating, whichever is lower.

The ladders shall be constructed from hollow steel tubing according to ASTM C 1015. Steel plate shall be according to ASTM A 572 with a minimum yield strength of 450 mPa (65 ksi). Step bolts (rungs) shall be according to ASTM A 394. Tubing for rungs shall be according to ASTM A 7. Bolts shall be according to ASTM A 307.

The ladder set shall be constructed such that the ladder set will fit light towers where the ladder clips shall be 1.8 m (6 ft.) above base plate with alternate 900 mm (36 inches) and 250 mm (10 inches) spacing thereafter, for the entire length.

Ladder rungs shall be placed in a staggered arrangement at 450 mm (18-inch) intervals with the top ladder being a working ladder with rungs on both sides of the ladder. Each ladder section shall be 1.4 m (4.5 ft.) long

and weigh no more than 13.6 kg (30 lbs.). Each ladder set shall be hot dipped galvanized according to AASHTO M 111.

(j) Power Receptacles and Plugs. Power receptacles and plugs shall be circuit-breaking devices which shall mate with each other.

The plugs and receptacles shall be 4-wire 4-pole, 600 volt, 60 ampere weatherproof devices according to UL Standard 498 and International Electrical Commission Standard 309. The devices shall be listed by the manufacturer as suitable for make and break operation at rated current.

Components and insert assemblies shall be interchangeable to accept either pin or socket inserts to allow either plug or receptacle to be configured in an energized or deenergized condition, i.e. reverse-contact configurations shall be available. Locations of reverse-contact devices shall be as indicated.

Each plug or receptacle connection to power cord shall be complete with a suitable non-metallic sealing connector body with a wire mesh strain relief. Other plugs and receptacles shall be complete with suitable sealing angle-adapter panel of box mounting bodies, as applicable and shall be complete with back-boxes if so dictated by the power distribution configuration.

Each plug and each receptacle shall be complete with a retained flap-type or retained screw-on cover.

Plugs and receptacles shall be water-tight, dust-tight, and chemical resistant and be suitable for use when exposed to the weather and shall be applicable for safe use in harsh, wet weather conditions. The Engineer shall be the judge of applicability.

**1085.33 Light Tower Anchor Rod Assembly.** Anchor rods shall be straight and shall be according to AASHTO M 314 Grade 105 with a minimum CVN energy of 21 N·m (15 ft. lbs.) at -29 °C (-20 °F.). Nuts shall be according to AASHTO M 291M, Class 10 S (M 291, Grade DH). Washers shall be according to AASHTO M 293. No welding will be permitted on anchor rods or nuts. The anchor rods, nuts and washers shall be treated by the hot dipped galvanizing method according to AASHTO M 232. Anchor rod information shall be submitted for approval and shall be fully coordinated with tower requirements by the tower manufacturer.

### 1085.34 Control Equipment.

- (a) General. The completed controller shall be an Industrial Control Panel under UL 508.
- (b) Enclosures.
  - (1) Single Door Enclosure.
    - a. Cabinet. The cabinet shall be single door design, fabricated from 3 mm (0.125 inch) thick Type 5052-H32 aluminum or AISI 304 stainless steel. The cabinet door frame shall be double flanged on all 4 sides. When post mounted, the cabinet shall have a stiffener plate bolted to the bottom of the enclosure. All external hardware shall be stainless steel. The cabinet shall have a NEMA 3R rating. Where no dimensions are indicated, the cabinet

- shall be sized to adequately house all required components with ample room for arrangement and termination of wiring.
- b. Door. The door shall be constructed from the same material and thickness as the cabinet. The door shall be equipped with a 3 point latching mechanism with nylon rollers at the top and bottom. The door handle shall be stainless steel and shall have a minimum diameter of 13 mm (1/2 inches) and have a padlock provision. The door shall be sealed with a neoprene gasket. The door hinge shall be a heavy gauge continuous hinge with a 5 mm (1/4-inch) diameter stainless steel hinge pin. The hinge shall be secured with stainless steel carriage bolts and stainless steel nuts and locknuts. A linkage-arm system, of simple construction, shall be attached to the cabinet doors to secure them in a wide open position to insure safety during field operations.
- Vent. The cabinet shall be equipped with a vent on top, designed to exclude moisture, dirt, and insects.
- d. Post Top Mounting. The cabinet shall be mounted a top a 100 mm (4-inch) rigid aluminum schedule 40 conduit stem anchored to a cast aluminum pedestal base constructed of ASTM B26 or B108 A444-T4, A356.0-T61, or 356-T6 cast aluminum with an access handhole cover. The stem and base shall be painted as specified for the cabinet.
- e. Base Mounting. Where indicated, the cabinet shall be mounted atop an enclosure base constructed from the same materials as the cabinet and of the same cross-section as the cabinet. The base extension shall be painted as specified for the cabinet. When a base extension is used, the foundation shall extend 300 mm (12 inches) above ground.
- f. Work Pad. Except where the cabinet is facing a sidewalk, a poured, 100 mm (4-inch) thick concrete pad, not less than 1.2 m (48 inches) square shall be provided in front of the cabinet.

### (2) Double Door Enclosure.

- a. Cabinet. The cabinet shall be of the dimensions shown on the plans and fabricated from 3 mm (1/8 inch) thick aluminum alloy No. 3003-H14. The cabinet shall comply with ANSI C33.71 and UL 50 and be reinforced with aluminum angles.
- b. Doors. The doors shall have stainless steel hinges. The door handle shall be stainless steel, a minimum diameter of 13 mm (1/2-inches) and have a padlock provision. The doors shall be gasketed to exclude the entry of moisture, dirt, and insects. A linkage-arm system, of simple construction, shall be attached to the cabinet doors to allow securing in a wide open position during field operations.
- c. Insulation. The interior compartment shall be insulated on the inside of the sides, back, top, bottom, and inside of the doors with 25 mm (1 inch) thick polyisocyanurate rigid foam insulation board. The foam board shall have foil facers on each side. The side facing the interior of the cabinet shall have a white tinted foil facer with a satin finish. The insulation shall have a minimum aged

thermal resistance (R-value) of 8 at a 4 °C (40 °F.) mean temperature. The insulation shall comply with Federal Specification HH-I-1972/1, Class 2.

- Mounting. The cabinet shall be mounted as indicated on the plans.
- e. Work Pad. The working pad shall be according to Article 1085.34(b)(1)f above.

### (3) Wall Mount Enclosure.

- a. Cabinet. The cabinet shall be a wall mounted type, NEMA 4X, not less than 14 gauge Type 304 stainless steel of the dimensions shown on the plans. The cabinet shall be sized to adequately house all required components with ample room for arrangement and termination of wiring. All seams shall be continuously welded with stainless steel weld wire.
- b. Door. The front of the cabinet shall have a hinged stainless steel door equipped with a handle and latching device suitable for installing a padlock. The door shall be gasketed to exclude the entry of moisture, dirt, and insects. The cabinet door shall be made of not less than 14 gauge stainless steel, Type 304. A print pocket shall be attached to the inside of the door. The enclosure shall have a continuous stainless steel hinge welded to the door and to the enclosure. The door shall be held closed by means of captive clamps fabricated from 12 gauge stainless steel and held in place with stainless steel hex head bolts. The clamps are to incorporate a depth stop to insure uniform sealing pressure at all clamp points.
- Finish. The enclosure shall be finished to a #3 polish. Painting
  of the stainless steel enclosure will not be required.

## (c) Finish.

- Unfinished Enclosures. Stainless steel enclosures shall not be painted.
- (2) Finished Enclosures. All aluminum enclosures shall be finished.

The cabinet shall be cleaned before painting inside and outside with oxalic acid for 5 to 10 minutes, or as otherwise recommended by the paint manufacturer and approved by the Engineer, to etch the metal surfaces.

The cabinet shall then receive 2 sprayed coats of white polyamide epoxy primer witha corrosion inhibitor applied inside and outside to all surfaces. The primer shall have a solids content, by volume of not less than 65% + 3% and each coat shall be applied to a thickness of 0.076 to 0.125 mm (3-5 mils).

All surfaces, interior and exterior, shall receive 1 final coat of silicone alkyd enamel paint. The finish paint shall have a solids content, by volume, of not less than 53% + 3%, and shall be applied to a thickness of 0.038 to 0.064 mm (1.5-2.5 mils).

The color of the finish paint shall be ANSI Standard No. 70 Sky Gray or as specified by the Engineer.

The finish shall be applied according to the paint manufacturer's recommendations and the manufacturer shall certify, in writing, to the Department, that the finish has been applied properly.

Submittal data submitted for approval shall address the requirement for the paint manufacturer's certification and shall include a standard, single source paint warranty by the paint manufacturer of the controller manufacturer to the Department.

- (d) Identification. The cabinet door shall have a stainless steel name plate of the dimensions and engraving indicated on the plans.
- (e) Control Components.
  - (1) Time Switch. Each controller shall hae an electric time switch for automatic control of highway lighting circuits operating on a daily schedule having a fixed relation to sunrise and sunset. Turn-on and Turn-off times shall be adjustable +/- 45 minutes from sunrise and sunset. All settings shall be field adjustable without special tools. Complete installation instructions, details on wiring connections, and information on time setting, manual operation, and necessary adjustments shall be furnished with each time switch.

The time switch shall be a microprocessor-based 2-channel controller with astronomic functions on both channels. The latitude shall be adjustable from 10 to 60 degrees in the Northern hemisphere. Latitude changes shall be user setable without the use of special tools.

The time switch shall be programmable in an AM/PM format, with a resolution of 1 minute or better. The time switch shall automatically adjust for daylight saving time and have automatic leap year correction and operate on 240 volts AC without the use of an additional transformer.

A battery backup shall be integral with the controller and shall use a nickel-cadmium battery. The battery backup shall provide power to the controller memory for a minimum of 72 hours in the event of power failures.

The published operating temperature range of the time switch shall be from -30 °C to 70 °C.

The time switch output relay contacts shall be rated sufficiently to handle the inrush current of two 200-ampere contactors. The time switch shall have a NEMA Type 1 enclosure as a minimum. The time switch programming instructions shall be moisture-proof and permanently affixed to the time switch or as otherwise approved by the Engineer.

- (2) Photocell Control System.
  - General. The photocell shall consist of a metal electrode, molecularly bonded to a ceramic wafer, and coated with cadmium-sulfide. The photo cell shall be highly corrosion

resistant without "Plastic dipping" with a nominal 484 mm<sup>2</sup> (0.75 sq. inches) in surface area. Color response of the cell shall be such that a maximum sensitivity is in the blue-green portion of the color spectrum.

- b. Switching Relay. The "On-Off" switching operations shall be accomplished by a normally closed contact which will be operated by means of an electro-magnetic relay. The response time shall be less than one second time delay for turn-on and three to thirty seconds time delay to prevent the "Turn-off" due to the light flashes of less than 108 lux (10 foot candles). Photocell shall be capable of less than one second time delay for both turn-on and turn-off when tested in full daylight. In the event of a circuitry failure, the lights will be turned on, or remain on.
- c. Surge Arrester. Overvoltage protection shall be provided for the control components and the load circuit by the means of an explusion type surge arrester capable of passing the surge outlined in ANSI C136.10 except follow current is 10,000 amps.
- d. Chassis and Enclosure. The base of the unit shall be manufactured on a 75 mm (3 inch) wide, solid thermoset phenolic base. The bottom of the base shall have an integral, locking type, brass 3 prong plug according to NEMA specification SH16-1962. The gasket shall be of a cross-linked polyethylene to assure moisture proof seal to the luminaire socket.
- e. Electrical. The control must be able to operate over the range of 105-130V, 60 Hz. AC (120 V Nominal). Its direct load rating shall be 1000 watts Incandescent load and 1800 VA Mercury Vapor, High Pressure Sodium or other H.I.D. load.
- f. Environmental. The control shall be stable and reliable over an operating temperature range of -55 °C (-65 °F.) to 70 °C (158 °F.).
- g. Operating Levels. Each control furnished shall be calibrated for a "Turn-on" setting of 5.4 to 22.5 lux (0.5 to 2.1 foot candles) of natural illumination and the "Turn-off" setting shall not exceed four times the "Turn-on" setting.
- (3) Circuit Breakers. All feeders, branch circuits, and auxiliary and control circuits shall have overcurrent protection. The overcurrent protection shall be by means of circuit breakers.

Circuit breakers shall be standard UL-listed molded case, thermal-magnetic bolt-on type circuit breakers with trip-free indicating handles.

Circuit breakers shall have a UL-listed interrupting rating of not less than 10,000 rms symmetrical amperes at rated circuit voltage for which the breaker is applied.

Multi-pole circuit breakers larger than 100 ampere size shall have adjustable magnetic trip settings.

The number of branch circuit breakers shall be as indicated on the

Control Cabinet detail drawing or as indicated in the lighting system wiring diagram which ever is greater plus 2 spare circuit breakers.

(4) Contactors. Contactors shall be electrically operated, electrically or mechanically held, as specified, with the number of poles required for the service and with operating coil voltage as indicated. Ampere rating of contactors shall be not less than required for the duty shown and shall otherwise be rated as indicated.

Contactors shall be complete with a non-conducting inorganic, non-asbestos subpanel for mounting.

Contactors shall be mechanically held and shall be complete with coil-clearing contacts to interrupt current through the coil once the contactor is held in position.

The main contactor contacts shall be the double break, silver to silver type. They shall be spring-loaded and provide a wiping action when opening and closing. The contacts shall be renewable from the front panel, self-aligning, and protected by auxiliary arcing contacts.

The line and load terminals shall be pressure type terminals of copper construction and of the proper size for the ampere rating of the contactor.

A lever for manual operation shall be incorporated in the contactor. Protection from accidental contact with current-carrying parts when operating the contactor manually shall be provided.

The contactor operating coil shall operate at 240 volts, single phase. Contactors shall be 2-pole devices with continuous rating for 200 amperes per pole at 480 Volts AC.

Open and closed positions shall be clearly indicated and labeled in permanent manner as approved by the Engineer.

(5) Auto/Manual Switches. The cabinet shall be equipped with automatic and manual operating controls via 2 single pole double throw switches, one being a maintained-contact manual-automatic selector switch and one being a momentary-contact manual on-off switch with a center rest position. Both switches shall be premium specification grade, rated for the applied duty but not less than 20 amperes at 240 volts and each shall be mounted in a 100 mm (4-inch) square box with cover.

The control circuit shall have overcurrent protection as indicated and as required by NEC requirements.

- (6) Ground & Neutral Bus Bars. Separate ground and neutral bus bars shall be provided. The ground bus bar shall be copper, mounted on the equipment panel, fitted with 22 connectors of the type shown on the plans, as a minimum. The neutral bar shall be similar. The heads of connector screws shall be painted white for neutral bar connectors and green for ground bar connectors.
- (7) Interior Lighting and Receptacle. The cabinet shall have an auxiliary device circuit at 120 volts single phase to supply a convenience receptacle and cabinet light. Where 120 volts is not available directly

from the service voltage, and outdoor dry type step-down transformer not less than 1 KVA shall be provided.

The auxiliary circuit, including transformer primary and secondary, shall have overcurrent protection according to NEC requirements.

The cabinet shall be equipped with an interior, 60-watt incandescent lighting fixture of the enclosed-and-gasketed type, switched from a single pole, single throw, 20 ampere switch. The switch shall be premium specification grade in a suitable 100 mm (4-inch) box with a cover.

The cabinet shall be equipped with a 20 ampere duplex receptacle, ground fault interrupting, premium specification grade in a 100 mm (4-inch) square box with cover, for 120 volt auxiliary use.

(f) Wiring and Identification. Power wiring within the cabinet shall be of the size specified for the corresponding service conductors and branch circuits and shall be rated RHH/RHW, 600 volts.

Control and auxiliary circuit wiring shall be rated RHH/RHW or MTW with jacket, 600 volts.

All power and control wiring shall be tagged with self-sticking cable markers and shall be stranded copper. When the contract drawings do not specifically indicate assigned wire designations, the manufacturer shall assign wire designations and indicate them on the shop drawings.

All switches, controls and the like shall be identified both as to function and position (as applicable) by means of engraved 2-color nameplates attached with screws, or where nameplate are not possible in the judgement of the Engineer, by the use of cloth-backed adhesive labels as approved by the Engineer.

The cabinet with all of its electrical components and parts shall be assembled in a neat orderly fashion. All of the electrical cables shall be installed in a trim, neat, professional manner. The cables shall be trained in straight horizontal and vertical directions and be parallel, next to, and adjacent to other cables whenever possible.

#### 1085.35 Luminaires.

- (a) General. The luminaire shall be optically sealed, mechanically strong and easy to maintain. The luminaire shall be designed as to its size, shape and weight so it does not aggravate the vibration characteristics of its respective pole and it shall be compatible with the pole and mast arm.
  - (1) Lamp Socket. The lamp socket shall be mogul type, porcelain enclosed, and be provided with grips, or other suitable means to hole the lamp against vibration. The rating of the socket shall exceed the lamp starting voltage, or starting pulse voltage rating.
  - (2) ANSI Identification decal. A decal, complying to the ANSI standard, shall be factory attached permanently to the luminaire. The information contained in the decal shall enable a viewer, from the ground level, to identify the lamp wattage and type of luminaire distribution.

(3) Optical Assembly. The reflector shall be made of aluminum sheet of such grade quality that the reflecting surface shall have a specular finish, the reflection factor of the reflecting surface, as determined by the A.H. Taylor or Baumgartner Reflectormeter, shall not be less than 78% and the reflecting surface shall have a dense protective coating of oxide not less than 0.012 mg/mm² (7.5 milligrams per square inch), applied by the anodic oxidation process.

The reflector, the refractor or lens, and the entire optical assembly shall not develop any discoloration over the normal life span of the luminaire.

The luminaire shall be photometrically efficient. Luminaire efficiency, defined by the I.E.S. as "the ratio or luminous flux (lumens) emitted by a luminaire to that emitted by the lamp or lamps used within", shall not be less than 67%. Submittal information shall include published efficiency data.

### (4) Ballast

a. General. The ballast shall be integral to the luminaire. Integral ballast components shall be mounted in the rear of the luminaire on the inside of a removable door or on a removable mounting pad. Ballast wiring and lamp socket wiring shall be connected by means of a plug. Upon unplugging the ballast wiring the entire ballast assembly shall remove for maintenance. The mounting adjustments and wiring terminals shall be readily accessible. The removable door or pad shall be secure when fastened in place and all individual components shall be secure upon the removable element. Each component shall be readily removable for replacement.

High power factor ballasts shall have a power factor of 0.9 or higher.

Ballasts shall not be excessively noisy. Noticeable noisy ballasts, as determined by the Engineer, shall be replaced at the Contractor's expense.

The ballast shall provide lamp operation within lamp specifications for the rated lamp life at input design voltage range.

Submittal information shall include manufacturer's literature and date to confirm compliance with all specified requirements including an ANSI Standard Ballast Characteristic Graph (Trapezoid) diagram, with all items clearly identified.

The lampholer and ballast components shall be completely wired, with connections made to a heavy duty terminal board with plug-in (pressure) connectors. Leads shall not be smaller than #16 AWG conductors. These shall be coded by tagging and/or color coding for proper identification. A complete legible wiring diagram coordinated with the wire identifications shall be displayed at the convenient location on the interior of the luminaire.

b. High Pressure Sodium Reactor. The ballast shall be a high power factor, linear type, low loss reactor which is designed and rated for operation on a 240 volt, grounded neutral system. The ballast shall produce positive lamp ignition over a voltage range not less than  $\pm\,5\%$  of the nominal system voltage.

Operating characteristics shall produce output regulation not exceeding 35%. For this measure, regulation shall be defined as the ratio of the lamp watt difference between the upper and lower operating curves to the nominal lamp watts; with the lamp watt difference taken within the ANSI trapezoid parallel to the minimum lamp volt line. The ballast shall be designed to furnish proper electrical characteristics for starting and operating a high pressure sodium vapor lamp of the specified rating at ambient temperatures of -29 ° to 40 °C. The ballast windings shall be adequately impregnated and treated for protection against the entrance of moisture, insulated with Class H insulation, and able to withstand the NEMA standard dielectric test. The ballast shall include an electronic starting assembly.

The starter assembly shall be comprised of solid state devices capable of withstanding ambient temperatures of 85 °C. The starter shall provide timed pulsing with sufficient follow-through current to completely ionize and start all lamps. amplitude of the pulse shall be 2,500 volts, with a width of 1 microsecond at 2,250 volts, and shall be applied within 20 electrical degrees of the peak of the open circuit voltage wave with a repetition rate as recommended by the lamp manufacturer for the 60 cycle wave. The lamp peak pulse current shall be a minimum of 0.2 amperes. Proper ignition shall be provided over a range of input voltage from 200 to 244 volts. The starter component shall be field replaceable and completely interchangeable with no adjustment necessary for proper operation. The starter component shall have push-on or crimped type electrical terminations to provide good electrical and mechanical integrity and ease of replacement. Terminal configuration shall preclude improper insertion of plug-in The starter circuit board shall be treated in an components. approved manner to provide a water and contaminant-resistant coating.

The ballast shall have an overall power factor of at least 0.9 when operated under rated lamp load. The ballast shall withstand a 2,500 volt dielectric test between the core and widings without damage to the insulation. The ballast shall not subject the lamp to crest factor exceeding 1.8 and shall operate the lamp without affecting adversely the lamp life and performance.

Ballast losses, based on cold bench tests, shall not exceed 12 percent to a nominal 100 V. lamp at the nominal input voltage of 230 v. for 200, 250 and 310 watt lamps and 10% for 400 watt lamps. Ballast losses shall be calculated based on input watts at nominal voltage and nominal lamp watts as follows:

Percent Losses =  $\frac{W_j W_n}{W_n}$ 

Where:

W<sub>j</sub>- Input Watts at 230v W<sub>n</sub>- Nominal Lamp Watts

c. High Pressure Sodium Regulator. The ballast shall be a high power factor magnetic regulator (lag type) ballast and, except as specified herein, shall be as specified for high pressure sodium reactor ballasts.

The ballast shall produce positive lamp ignition over a voltage range not less than  $\pm$  10% of nominal system voltage. Operating characteristics shall produce output regulation not exceeding 20%. Ballast losses shall not exceed 20% for a nominal 100 v. 400 watt lamp and 25% for other sizes.

- d. Fluorescent, High Output. The ballast shall be mounted within the fixture and be designed to operate at 240 VAC, 60 Hz, with a high power factor. The ballast shall be capable of starting and operating 2 F72T12 rapid start, high output, cool white fluorescent lamps at a 800 mA current and a temperature of -29 °C (-20 °F.).
- e. Low Pressure Sodium. The ballast shall be suitable for use on a 240/480 volt, 60 Hz, single phase 3-wire electrical system. The ballast shall be designed for 240 V. nominal voltage operation and be able to start the lamp and control its operation continuously over an embient temperature range from -29 ° to +40 °C. The ballast may be magnetic, solid state or a hybrid of the two.

The ballast shall control the 240 V. nominal voltage within  $\pm$  10% variation for the 55 watt lamp. It shall regulate the output power to +5% for input voltage fluctuation of +10%.

The ballast shall have an overall power factor of at least 0.9 when operated under rated lamp load.

Total ballast losses shall not exceed 45% of nominal load for the 55 watt lamp.

The ballast shall withstand a 2,500 volt dielectric test between the core and windings without damage to the insulation.

The ballast shall not subject the lamp to a crest factor exceeding 1.8 and shall operate the lamp without affecting adversely the lamp life and performance.

(5) Photometric Performance. The luminaire photometric performance shall produce results equal to or better than those listed in the applicable Luminaire Performance Table or tables. Submittal information shall include computer calculations based on the controlling given conditions which demonstrate achievement of all listed performance requirements. The computer calculations shall be done according to I.E.S. recommendations and the submitted calculations shall include point-by-point illuminance, luminance and veiling luminiance as well as listings of all indicated averages and ratios as applicable. The program used to perform the calculations shall be identified on the submittal. Rounding of calculations shall not be allowed.

In addition to computer printouts of photometric performance, submittal information shall include:

- a. Descriptive literature
- b. Isofootcandle chart of horizontal lux (footcandles)
- c. Utilization curve
- d. Isocandela diagram
- e. Luminaire classification per ANSI designation
- f. Candlepower values at every 2.5 degree intervals
- g. Candlepower tables is to be provided on 130 mm (5 1/4 inch) diskette in the I.E. S. format.
- (6) Independent Testing. Independent testing of luminaires shall be required whenever the quantity of luminaires of a given wattage and distribution, as indicated on the plans, is 50 or more. For each luminaire type to be so tested, one luminaire plus one luminaire for each 50 luminaires shall be tested i.e. 75 luminaires would dictate that 2 to be tested; 135 luminaires would dictate that three be tested.

The Contractor shall select one of the following options for the required testing with the Engineer's approval:

- a. Engineer Factory Selection for Independent Lab: The Contractor shall propose an independent test laboratory for approval by the Engineer. The Contractor shall schedule travel by the Engineer to and from the luminaire manufacturer's plant for selection of the luminaire(s) for testing. The selected luminaires shall be marked by the Engineer and shipped to the independent laboratory for tests.
- b. Engineer Witness of Independent Lab Test: The Contractor shall propose an Independent test laboratory for approval by the Engineer. The Engineer shall select, from the project luminaires at the manufacturers facility or at the Contractor's storage facility, luminaires for testing by the independent laboratory. The Contractor shall schedule travel by the Engineer to and from the independent laboratory to witness the performance of the required tests.
- c. Independent Witness of Manufacturer Testing: The independent witness shall select from the project luminaires at the manufacturers facility or at the Contractor's storage facility, the luminaires for testing. The Contractor shall propose a qualified independent agent, familiar with the luminaire requirements and test procedures, for approval by the Engineer, to witness the

required tests as performed by the luminaire manufacturer. The Contractor shall schedule travel by the approved independent witness to and from the test location.

d. Engineer Factory Selection and Witness of Manufacturer Testing: At the Manufacturer's facility, the Engineer shall select the luminaires to be tested and shall be present during the testing process. The Contractor shall schedule travel by the Engineer to and from the Manufacturer's laboratory to witness the performance of the required tests.

In all cases, the selection of luminaires shall be a random selection from the entire completed lot of luminaires required for the contract. Selections from partial lots will not be allowed.

The selection of the testing option shall be presented with the information submitted for approval. The proposed independent laboratory or independent witness shall be included with that information.

The testing performed shall include photometric and electrical testig. Photometric testing shall be according to IES recommendations and as a minimum, shall yield an isofootcandle chart, with max candela point and half candela trace indicated, an isocandela diagram, maximum planned and maximum cone plots of candela, a candlepower table (House and street side), a coefficient of utilization chart, a luminous flux distribution table, and a complete calculations based on specified requirements and test results.

Electrical testing shall conform to NEMA and ANSI standards and as a minimum, shall yield a complete check of wiring connections, a ballast dielectric test, total ballast losses in watts and percent of input, a lamp volt-watt trace, regulation data, a starter test, lamp current crest factor, power factor (minimum over the design range of input voltage at nominal lamp voltage) and, a table of ballast characteristics showing input amperes, watts and power factor, output volts, amperes, watts and lamp crest factor as well as ballast losses over the range of values required to produce the lamp volt-watt trace.

The summary report and the test results shall be certified by the independent test laboratory or the independent witness, as applicable, and shall be sent by certified mail directly to the Engineer. A copy of this material shall be sent to the Contractor at the same time.

Should any of the tested luminaires of a given distribution type and wattage fail to satisfy the specifications and perform according to approved submittal information, the luminaire of that distribution type and wattage shall be unacceptable and be replaced by alternate equipment meeting the specifications with the submittal and testing process repeated in their entirety; or corrections made to achieve required performance. In the case of corrections, the Contractor shall advise the Engineer of corrections made and shall request a repeat of the specified testing and, if the corrections are deemed reasonable by the Engineer, the testing process shall be repeated. The number of luminaires to be tested shall be the same quantity as originally tested. Luminaires which are not modified or corrected shall not be retested without prior approval from the Engineer.

Eight weeks advance notice will be required for the Engineer's travel.

Coordination shall be the Contractor's responsibility. Failure to coordinate arrangements and notice shall not be grounds for additional compensation or extension of time.

Submittal information shall include a statement of intent to provide the testing as well as a request for approval of the chosen laboratory.

- (b) Roadway Luminaire.
  - (1) Horizontal Mount.
    - a. General. The effective projected area of the luminaire shall not exceed 0.149 m<sup>2</sup> (1.6 sq. ft.).

The luminaire shall slip-fit on a 50 mm (2 inch) pipe arm, and shall have a barrier to limit the amount of insertion. It shall not be necessary to remove more than the cover, reflector, and refractor or lens to mount the luminaire.

The luminaire shall be provided with a leveling surface and shall have a 4-bolt anchoring/attachment means so as to be capable of being tilted by +/-3 degrees and rotated to any degree with respect to the supporting arm.

The light distribution shall be medium - cutoff Type III (M-C-III), as defined in the "American National Standard Practice of Roadway Lighting", ANSI-IES (RP-8).

The beam of maximum candlepower for luminaires specified or shown to have "medium" distribution shall be at 70 degrees from horizontal +/-2 degrees. Submittal information shall identify this angle.

- b. Housing. The housing shall be made of cast aluminum or cast aluminum alloy. On aluminum alloys that darken due to atmospheric exposure, the finish shall be textured aluminum and shall be colored by painting with a suitable lacquer, enamel, or other paint. The paint shall be the manufacturer's standard gray. The external latches, nuts, screws, washers, pins and other parts shall be made of stainless steel or galvanized steel.
- c. Lens/Refractor. Luminaires shall have lenses made of crystal clear, impact and heat resistant flat glass. The lens shall be held in such a manner as to allow for its expansion and contraction. Where refractors are specifically indicated or permitted, they shall be prismatic impact and heat resistant glass.
- d. Gasketing. When closed for operation, the optical assembly shall be sealed with a gasket against the entry of moisture, dirt, and insects. The cover-reflector and socket-reflector junctions shall be sealed against the entry of moisture, dirt and insects with a thick, high density dacron felt gasket, securely attached by mechanical means, such as a retaining lip, or by a wide-temperature permanent adhesive in a manner acceptable to the Engineer. Submittal information shall include data relative to gasket thickness and density and the means of securing it in place. An alternative gasket material may be approved by the

Engineer. There shall be a provision for thermal breathing. A charcoal filter may be used, subject to approval by the Engineer.

## (2) Multi Mount.

- a. General. The luminaire shall be a pole top, vertical slip fitter, single lamp fixture. The maximum weight of the luminaire shall be 45 kg (100 lbs.) and its effective projected area shall not exceed 0.36 m<sup>2</sup> (3.85 sq. ft.).
- b. Housing. The luminaire shall be enclosed design with an optical system consisting of a single piece of hydroformed, specular, anodic finish, aluminum reflector and a prismatic borosilicate, thermal shock resistance glass refractor. The lamp socket shall be permanently attached to the reflector to assure proper lamp arc center positioning. The housing of the luminaire shall be cast aluminum with a baked enamel finish. It shall consist of a main housing containing the reflector and electrical equipment, and a refractor housing. The refractor housing shall be securely attached to the main housing by means of 2 stainless steel top hinges and 2 trigger actuated bottom latches. The refractor housing shall be readily removable for luminaire servicing.
- c. Gasket. Seals and/or gaskets shall be provided at all critical points to prevent entry of contaminants. A breathing seal, polyester fiber gasket shall be provided at the lower juncture of the housings to filter air entering the fixture. Neoprene Gasketing shall be used at all other junctures between the housings.
- d. Mounting. The luminaire shall be equipped with a vertical slip-fitter and a leveling aiming adjustment assembly for rapid and versatile field installation. The slip-fitter shall accept 60 to 75 mm (2 3/8 to 3 inches) O.D. poles or tenons. The assembly shall provide a horizontal leveling adjustment of  $\pm$  15 degrees about a standard luminaire axis position of 45 degrees.
- e. Alignment. To provide maximum illumination on the roadway, the Contractor shall obtain from the luminaire manufacturer, calculations providing the proper vertical angle and orientation for each luminaire location. Subsequent orientation and vertical angle adjustment required from a final inspection shall be considered part of the pay item and additional compensation will not be allowed.

Luminaires supplied with corrosion-resistant steel poles shall be furnished with a bronze baked enamel finish. When supplied with an aluminum pole, the color shall be munsell grey.

## (3) Rectlinear.

- a. Housing. The luminaire housing shall be made of aluminum. The housing shall be die-cast aluminum or extruded aluminum. Any welds made to the housing shall be continuous. Seems shall be ground smooth without the use of fillers such as silicone or plastic materials. The housing shall be free of burrs and protrusions.
- Lens and Frame. The lens frame shall be held snugly in such a manner as to allow for its expansion and contraction. The lens

shall be held within a metal frame which shall be mounted to the housing. The lens frame assembly shall hinge down for access to the internal components of the luminaire. The hinge arrangement may be heavy-duty pin-type hinges or other arrangements approved by the Engineer but the assembly shall assure that the lens frame will open for clear access to the inside of the luminaire and that easy positive alignment of the frame upon re-closing, without lifting an/or shifting or the frame, is assured. The lens frame shall be held closed by heavy-duty, captive, stainless steel quarter turn slot screw type fasteners conforming to the specifications for hardware.

- Ballast Mounting. The ballast shall be integral to the luminaire C. Integral ballast components shall be mounted in the rear of the luminaire on the inside of a removable door or on a removable mounting pad. Ballast wiring and lamp socket wiring will be connected by means of a plug. Upon unplugging the ballast wiring, the entire ballast assembly shall be removable for maintenance. The mounting adjustments and wiring terminals shall be readily accessible. The removable door or pad shall be secure when fastened in place and all individual components shall be secure upon the removable element. Each component shall be readily removable for replacement. The ballast components shall be mounted and fastened within the luminaire housing in a manner such that the components will remain secure and capable of withstanding the pole vibrations. Each component shall be readily removable for replacement.
- d. Optical Assembly. The reflector shall be made of aluminum and may either be segmented or hydroformed. The reflecting surface shall have a specular finish and have a dense protective coating or oxide not less than 0.012 mg/mm² (7.5 mg per sq. inch), applied by the anodic oxidation process. A glass reflector finish may be substituted in place of the above oxide coating. The glass finish shall be chemically bonded to the reflector and shall be flexible, impact resistant, and heat resistant.

Segmented reflectors, if used, shall have extensive bracing and support of the reflective segment members to minimize the potential for accident bending of the segments during installation or maintenance.

- e. Finish. The luminaire housing shall be chemically cleaned and treated prior to the application of the luminaire finish. The luminaire shall have a heavy duty weather-resistant baked acrylic enamel finish or other finish as approved by the Engineer. The luminaire finish shall be a dark bronze color which shall be coordinated with the color of the poles. Submittal material shall include evidence of coordination of the finish color as well as a finish color sample.
- (c) High Mast Luminaire.
  - (1) General. The luminaire shall be designed and manufactured for high mast tower use. It shall be compatible for mounting heights in excess of 30 m (100 ft.) with 130 km/h (80 mph) wind speeds and 167 km/h (104 mph) gusts. It shall be designed to withstand the physical

stresses associated with such duty including shocks and vibrations.

- (2) Horizontal Mount.
  - a. Housing. The luminaire housing shall be made of die cast aluminum with the top and sides continuous without seams or welds. The housing shall be free of burrs and protrusions.
  - b. Hardware. All hardware shall be stainless steel or of other high-strength corrosion resistant material approved by the Engineer and shall be of extra heavy duty construction.

Fasteners such as quarter-turn clips shall be heavy spring loaded type with large, deep straight slot heads, complete with receptacle and shall conform to Military Specification MIL-F-5591. Other hardware shall conform to Military Specifications, wherever applicable.

All hardware shall be captive, not susceptible to falling from the luminaire during maintenance operations. This shall include lens/lens frame fasteners as well as hardware holding the removable ballast/electronic components in place.

c. Lens and Lens Frame. The lens shall be made of crystal clear, impact and heat resistant glass which shall be flat or convex but convex lenses shall not be more than 95 mm (3 3/4 inches) convex from flat. The luminaire shall meet the cutoff and veiling luminaire (glare) criteria specified elsewhere herein regardless of the lens configuration.

The lens frame shall be held snugly yet in such a manner as to allow for its expansion and contraction. The lens shall be held within a metal frame which shall be mounted to the housing. The lens frame assembly shall hinge down for access to the internal components of the luminaire. The hinge arrangement shall be heavy- duty pin-type hinges or other arrangements approved by the Engineer. The assembly shall assure that the lens frame opens for clear access to the inside of the luminaire. There shall be positive alignment of the frame upon reclosing, such that no lifting and/or shifting or the frame occurs.

The lens frame shall be held closed by heavy-duty, captive, stainless steel quarter turn slot screw type fasteners conforming to the specifications for hardware, herein.

d. Reflectors. The reflector shall be made of hydroformed aluminum. The reflecting surface shall have a specular finish and have a dense protective coating or oxide not less than 0.012 mg/mm² (7.5 mg/sq. inch), applied by the anodic oxidation process. A glass reflector finish may be substituted in place of the above oxide coating. The glass finish shall be chemically bonded to the reflector and shall be flexible, impact resistant, and heat resistant.

The reflector and lamp socket assembly shall be capable of being rotated + or - 75 degrees (150 degrees total) with respect to the mounting arm. Orientation shall be as directed by the Engineer.

The luminaire shall be equipped with identifying markings to indicated the mounted orientation. Luminaire installation shall include engraved banding of the mounting arms to designate proper orientation.

When the design of the luminaire is such that the reflector must be removed or disconnected to gain access to the ballast or when the reflector must be hinged open or otherwise moved to relamp the luminaire, the reflector shall remain captive to the luminaire and shall not interfere with the access required.

Removal of the reflector regardless of luminaire position, shall not require or invite handling of the essential reflective portion of the assembly. When required, the reflector shall be equipped with clearly identified handles, lifting tabs or the lid for reflector removal.

The reflector and the entire optical assembly shall not develop any discoloration over the normal life span of the luminaire.

- e. Gasketing. When closed for operation, the optical assembly shall be sealed with a gasket against the entry of moisture, dirt, and insects. The lens frame-optical assembly junction shall be sealed with a thick, high-density Dacron felt gasket securely attached to the optical assembly or lens frame. The socket support-reflector junction shall also be sealed with a suitable gasket. There shall be a provision for thermal breathing and a charcoal filter for air entering the sealed optical assembly.
- (3) Vertical Mount. The optics shall be arranged so the pattern can be rotated 360° around its vertical axis with a position indication. Maximum total utilization on the street side shall not be less than 42%.

For an open-bottom luminaire, the reflector shall be constructed of pressed, prismatic, annealed, borosilicate glass. The luminaire shall operate as an open-ventilated unit permitting free flow of air upward by chimney action through the optical assembly.

For an enclosed bottom luminaire, the reflector shall be of Alzak finished spun aluminum process with "flats' in the upper portion to redirect reflected light away from the arc tube of the lamp. The reflector assembly shall be enclosed and gasketed and shall include a filter to allow breathing. The bottom cover of the luminaire shall be made of clear, tempered, heat and shock-resistant glass, and shall be attached to the reflector housing by means of a hinged, gasketed door frame and 5 or more toggle latches. The socket mounting assembly shall have a provision of adjustment for the maximum candle-power in the field.

All hardware shall be made of stainless steel.

## (d) Underpass Luminaire

(1) General. The underpass luminaire shall be suitable for lighting a roadway underpass at approximate mounting height of 4.5 m (15 ft.) from a position suspended directly above roadway or attached to a wall or pier.

The luminaire shall provide the lighting distribution described, be optically sealed, mechanically strong and easy to maintain. The reflector, wiring terminals, and ballast components shall be readily accessible. When closed for operation, the optical assembly and the ballast assembly shall be sealed against the entry of moisture, dirt and insects. It shall not be necessary to remove more than the cover, reflector and lens to mount the luminaire.

The unit shall be heavy duty, suitable for highway use and shall have no indentations or crevices in which dirt, salt, or other corrosives may collect.

All removable components and hardware, except for the ballast tray, shall be held captive.

## (2) Low Pressure Sodium.



- Housing. The housing, ballast door, and lens frame shall be made of 0.076 mm (0.0299 inch) (22 gauge) minimum thickness stainless steel. All seams shall be continuously welded with stainless steel welding wire. All internal and external hardware shall also be made of stainless steel, Type 304. All seams in the housing enclosure shall be constructed of the dutch-lip folding type and be welded by continuous welds. The lens frame of the stainless steel housing shall be sufficiently strong to hold the lens firmly in place. When closed, the frame shall be held securely in place with heavy duty quarter turn fasteners held captive in the frame and gasketed with neoprene washers or by heavy duty stainless steel latches acceptable to the Engineer. It should be possible to open and close the guarter turn fasteners/latches without the use of tools. The corners of lens frame shall be mitered and tack welded. When in open position, it shall be possible to un-hinge and remove the frame for maintenance. There shall be a lead free hinge pin for easy rehinging of the frame and it shall be held captive via a chain or by other means approved by the Engineer.
- b. Ballast Mounting. The ballast shall be mounted on a removable tray constructed from not less than 1.22 mm (18 gauge) stainless steel. All ballast components shall be mounted on this tray. When installed the tray shall be held securely in place with heavy duty captive quarter turn fasteners which can be easily operated without the use of tools. The tray shall unhinge and be removable for servicing. There shall be a lead hinge pin for easy rehinging of the ballast tray. The primary and secondary ballast sires shall have keyed lug type connectors for ease of servicing. It shall not be possible to misconnect the wiring connectors.
- c. Lens and Lens Frame. The lens shall be made of prismatic, crystal clear, impact and heat resistant borosilicate glass. Injection or vacuum molded acrylic or polycarbonate refractors or lenses shall be acceptable only when ultraviolet radiation is totally absent. Acrylic or polycarbonate refractors or lenses shall be heat and impact resistant and shall not discolor. The lens shall be held in such a manner as to allow for its expansion and contraction, due to temperature variation.

The lens shall be held within a lens frame. The frame shall be sufficiently strong to hold the lens firmly in place. When closed, the frame shall be held securely in place with heavy duty quarter turn fasteners, held captive in the frame, which could be easily operated without the use of tools. When in open position, the frame shall unhinge and remove.

- d. Reflector. The reflector shall be of aluminum sheet of not less than 0.63 mm (0.025-inch) thickness. The reflector may have a specular finish with either an oxide or glass coating or it may have a baked white enamel finish.
- e. Gasketing. The junction between the lens frame and the housing, the ballast compartment door and the housing, and the lamp socket and reflector junction shall be sealed with a high temperature silicone rubber or dacron felt gasket. The gasket seal shall be waterproof. The junction between flexible conduit connections to the luminaire shall withstand entry of water when subjected to a water jet pressure of 207 kPa (30 lbs. per sq. inch), tested under laboratory conditions.
- f. Mounting Bracket. The luminaire mounting brackets shall be attached to the luminaire housing. The brackets shall allow the luminaire housing to be rotated  $\pm$  30 degrees in marked increments of 5 degrees. The brackets shall be made of 3.05 mm (11 gauge) minimum thickness stainless steel, attached rigidly to the housing in a manner satisfactory to the Engineer. The luminaire shall have an opening in the housing for installation (by others) of a 25 mm (1 inch) diameter flexible conduit.
- g. Testing. Submittal information shall include documentation of previous independent testing demonstrating compliance with these specifications, including water jet testing of the enclosure at not less than 14 kg (30 lbs.) of pressure for a duration of 2 minutes.
- h. Fusing. Each luminaire shall include a fuse, one for each phase conductor, in a vibration resistant screw-in fuseholder mounted inside the luminaire enclosure suitable for use in this application.

## (3) High Pressure Sodium

- a. General. The Underpass luminaire shall be complete with all supports and hardware, identification bracket and decals, and appurtenant mounting accessories. The underpass luminaire shall be suitable for lighting a roadway underpass at approximate mounting height of 4.5 m (15 ft.) from a position suspended directly above roadway or attached to a wall or pier.
- b. Housing. The stainless steel housing, and lens frame shall be made of 16 gauge minimum thickness stainless steel, Type 304. All internal and external hardware shall also be made of stainless steel. All seams in the housing enclosure shall be welded by continuous welds. The lens frame of the stainless steel housing shall be sufficiently strong to hold the lens firmly in place. When closed, the frame shall be held securely in place with heavy duty fasteners held captive in the frame and gasketed with neoprene

washers or by heavy duty stainless steel latches acceptable to the Engineer. It should be possible to open and close the fasteners/latches without the use of tools. The corners and seams of the lens frame shall be tack welded. When in open position, it shall be possible to un-hinge and remove the frame for maintenance and shall be held captive via a chain or by other means approved by the Engineer.

- c. Ballast Mounting. The ballast shall be mounted on a stainless steel, easily removable tray constructed from not less than 1.22 mm (18 gauge) stainless steel. All ballast components shall be mounted on this tray. When installed the tray shall be held securely in place with heavy duty captive fasteners which can be easily operated without the use of tools. The tray shall be removable for servicing. The primary and secondary ballast wires shall have keyed lug type connectors for ease of servicing. It shall not be possible to misconnect the wiring connectors.
- d. Lens and Lens Frame. The lens shall be made of 19 tempered crystal clear borosilicate glass. The lens shall be held within a lens frame. The frame shall be sufficiently strong to hold the lens firmly in place. The frame shall be sufficiently strong to hold the lens firmly in place. The frame shall not overlap the housing when closed. When closed, the frame shall be held securely in place with heavy duty fasteners, held captive in the frame, which can be easily operated without the use of tools. When in open position, the frame shall unhinge and be removable. The lens frame shall be hinged with a continuous stainless steel piano type hinge or other hinge arrangement as approved by the Engineer.
- e. Reflector. The reflector shall be hydroformed specular aluminum type. The reflector shall have an anodic coating not less than 0.007 mg/mm<sup>2</sup> (4.5 mg/sq. inch) and sealed in a hot water rinse having a closely controlled ph factor.
- f. Mounting Bracket. The 4 luminaire mounting brackets fabricated from 3.05 mm (11 gauge) stainless steel shall be welded to the luminaire housing. The luminaire shall have an opening in the housing for installation (by others) of a 25.4 mm (1 inch) diameter flexible conduit.
- g. Testing and Fusing. Testing and fusing shall be according to Article 1085.35(a)(6) and 1085.03.

## (e) Sign Luminaire

- General. The luminaire shall be suitable for lighting expressway guide signs. The fixture shall be UL Listed for wet locations.
- (2) Fluorescent.
  - a. Housing. The outer housing shall be constructed from 1.6 mm (0.064 inch) thick 3003-H14 aluminum. The housing shall have an extruded aluminum hinge, one half of which is an integral part of the housing.
  - Lens and Frame. The lens frame shall be made of extruded aluminum and have a continuous extruded neoprene gasket seal

to insure weatherproofing. The frame shall have a concealed retaining latch which locks the door open for servicing and shall include a safety chain. The frame shall have spring loaded toggle action latches. The lens shall be made of clear 3 mm (0.125 inch) thick acrylic.

- Lamp Holders. The lamp holders shall be end mounted, spring loaded, self-sealing, and self-aligning.
- Reflector. The reflector shall be made of 0.5 mm (0.020 inch) minimum thickness specular aluminum.
- e. Wiring. All wiring connections in the fixture shall terminate on molded phenolic, barriers type, heavy duty, terminal blocks rated for a maximum current of 30 amperes and maximum voltage of 3,300 volts. The terminal block shall accommodate No. 10 AWG wire and shall be legibly color marked to suit the ballast wire colors. All wiring, terminal blocks, and ballast shall be fully enclosed within the fixture so none of the above parts are exposed when relamping.
- f. Testing and Fusing. Testing and fusing shall be according to Article 1085.35(a)(b) and 1085.03.

# (3) High Pressure Sodium.

- a. Housing. The housing shall be heavy duty die cast aluminum which shall support and enclose the reflector, electrical assembly, and 30 mm (1 1/4 inch) conduit supports and shall interact with the hingeable door to provide a watertight lamp environment. A single piece weather resistant gasket shall seal the door to the housing when stainless steel door latch bolts are secured. The integrally cast hinge shall allow the door to stand open to allow full access to the electrical components. All hardware shall be stainless steel. All die cast aluminum surfaces shall be finished with a heavy duty coat of gray acrylic enamel. Housing shall be provided with pads for three point surface mounting.
- Lens and Frame. The lens shall be shock resistant tempered glass secured in a heavy duty die cast aluminum frame with selfsupporting hinges and an integral glare shield.
- c. Lamp Holders. The lamp holders shall be heavy duty, porcelain enclosed, nickle plated or stainless steel, factory prewired.
- d. The Reflector. The reflector shall be hydro formed aluminum with a bonded finish for corrosion resistance, durability and ease of cleaning.
- e. Wiring. All electrical components shall be prewired and tested after assembly. Ballast components shall be heat sunk against the cast aluminum housing. Ballast shall be lag-type magnetic regulator suitable for starting and operating the high pressure sodium lamp in an ambient temperature down to 4 °C (40 °F.).
- f. Performance. The optical assembly shall provide an illumination level on the sign face that does not exceed a gradient ratio of 2.0.
- (f) Waterway Obstruction Warning Luminaire. The luminaire shall be optically

sealed, mechanically strong, and easy to maintain. The luminaire shall meet all requirements set forth by the United States Coast Guard. Each light shall have 2 separate lamp cavities each equipped with fresnel lens and spring mounted, vibration resistant, medium, 600 watt, 250 volts, porcelain socket. The lamp cavities shall be either watertight, or they shall be weatherproof and bug-proof. The lamp shall be easily accessible for relamping through gasketed doors which are held captive by means of hinges or a brass chain. The navigation light shall have a cast bronze body and be Coast Guard approved. Nuts, bolts, thumb screws, hardware, and thread rods which are exterior, shall be stainless steel (300 series) or bronze. Hardware on the interior of the lamp cavity shall be stainless steel or bronze. The light shall have two 120 volt, 75 watt, 20,000 hour life, clear long life incandescent lamps. The auxiliary lamp transfer relay shall be enclosed in its own cast aluminum housing with gasketed weather-proof cover mounted as shown on the plans. It shall be suitable for mounting on the navigational luminaire function with a line variation of 120 VAC ± 20% and shall be protected from shock, vibration and humidity.

(g) Aviation Obstruction Warning Luminaire. Luminaires shall be 300 mm (12 inch) beacon type and constructed to meet all FCC and FAA requirements for continuous service under all weather conditions. The housing shall be constructed of heavy cast aluminum with cast aluminum globe support rings to accommodate two 360 ° red fresnel lenses or red color filters. The lamp cavities shall be vented weather, and insect proof. The light shall have two 120 volt, 620 watt, 3,000 hour life, long life incandescent lamps. Each luminaire shall be operated by a beacon flasher conforming to FAA regulations without field adjustment. It shall be a 2 circuit control rated for 2.0 kW maximum, continuous tungsten load up to 55 °C (131 °F.) ambient air temperature at 1,120 volts. Flash rate shall be 30 FPM 2/3 on, 1/3 off duty cycle. Normally closed solid state relay configuration shall prove a "lights on" condition for fail-safe operation. It shall be equipped with built-in surge and transient protection and furnished in a NEMA-3 enclosure.

## 1085.36 Breakaway Devices.

- (a) Breakaway Couplings
  - (1) General. Breakaway couplings shall be manufactured of cast aluminum. Certification shall be submitted from the supplier that the device used under the conditions of the particular design meets the AASHTO breakaway specification. Certification shall include test results performed by the manufacturer, supplier or others. If test results have been previously approved by a letter from the FHWA, a copy of the approval letter from FHWA should accompany the certification. The coupling shall not alter the bolt circle of the pole.

The breakaway device shall be vandal resistant and shall not adversely affect the light pole installation and maintenance or decrease the resistance of the light pole to non-collision type of design loading. The breakaway device shall be field attachable and detachable.

- (2) Breakaway Coupling Cover. The breakaway device shall have a cover enclosing the space between the bottom of the pole base plate and the foundation.
  - a. Aluminum Skirt. The cover shall be an aluminum skirt of a

- 2 piece design made of 3003 H14, or 5052 H32T aluminum alloy, 2 mm (0.080 inches) thick. The enclosure shall fit snugly around the breakaway devices between the bottom face of the pole base plate and top of the foundation. Vertical or horizontal movement of the enclosure will not be acceptable.
- b. Fiberglass Shroud. When specified, the cover shall be a molded fiberglass shroud. The shroud shall be designed as a one-piece fiberglass enclosure, capable of being installed over the base of the light pole and breakaway couplings, as shown on the plans. When installed on existing poles, the shroud may be a 2-piece assembly designed to be permanently joined in a manner which is tamper-resistant as approved by the Engineer. The shroud shall be dimensioned in a manner such that it will fit over light pole base designs with a bolt circle and shaft diameter as shown on the plans, and lateral movement shall be no greater than required to allow easy installation. The Contractor shall sumit all dimensions necessary to confirm a proper fit. The shroud color shall be applied in a manner applicable to current industry practice for this type of material and use. The color shall be as approved by the Engineer. The Contractor shall submit samples of colors and materials for selection.

# (b) Transformer Base

- (1) The breakaway device shall be a cast and welded aluminum transformer base type pole base. The breakaway device shall have a listing of approval by FHWA to AASHTO breakaway requirements. This shall require compliance to 1985 AASHTO requirements according to "Standard Specifications of Structural Supports for Highway Signs, Luminaires and Traffic Signals" published by AASHTO. Submittal information shall document the approval listing.
- (2) The device shall be approximately 430 mm (17 inches) high and shall have a large fiberglass or polyethylene access door of a color to match the base finish which shall be held in place with a button-type tamper resistant stainless steel screw or other means approved by the Engineer. The polyethylene access door shall be fabricated from a high density polyethylene. The door shall withstand temperature extremes of -60 °C to +65 °C (-76 °F. to +150 °F.). Ultraviolet light inhibitors shall also be incorporated into the door material. The door shall be gusseted and have tabs on the bottom to lock into the transformer base door frame.
- (3) The appearance of the breakaway device shall be of such general configuration as not to detract from the aesthetic value of the light pole.
- (4) 290 mm (11.5 inch) Pole Bolt Circle Devices. Breakaway devices for poles having nominal 290 mm (11.5-inch) bolt circles shall accommodate bottom (foundation) bolt circles ranging roughly 255 mm to 300 mm (10 to 12 inches) and shall accommodate top (pole) bolt circles ranging roughly 265 mm to 300 mm (10.5 to 12 inches). The 290 mm (11.5-inch) bolt circle devices shall have a natural standard aluminum finish.
- (5) 380 mm (15-inch) Pole Bolt Circle Devices. The Contractor shall coordinate device type with the size of the foundations in the contract.

The 380 mm (15 inch) bolt circle devices shall have a natural aluminum finish.

- (6) Flared Base Device. The bottom foundation bolt circle shall have a range of 380 to 43 mm (15 to 17 inches) and shall accommodate to (pole) bolt circles having a range of 330 to 380 mm (13 to 15 inches).
- (7) Straight Base Device. The bottom foundation bolt circle shall have a bolt circle of 380 mm (15 inches) and shall accommodate top (pole) bolt circles of 380 mm (15 inches). Washers shall be used between the device and the foundation as directed by the device manufacture. These washers shall not be used to level the pole. An equal number of washers shall be used on the anchor bolts.

# 1085.37 Signal Head and Optically Programmed Signal Head.

- (a) Face. The signal face shall be of sectional design and expandable.
- (b) Housing and Door. The cast aluminum housing or door shall be according to the alloy and tensile requirements of the ITE Standards. The polycarbonate housing or door shall be made of Ultra-Violet stabilized polycarbonate resin and shall be molded in one piece with a minimum thickness of 2.25 mm (0.09-inch).

The top and bottom of each housing shall have an opening to accommodate standard 35 mm (1.5 inch) pipe fittings and brackets. The top and bottom openings shall each have an interlocking ring integral with the signal section. The locking ring shall have 72 teeth, permitting rotation of the signal section in 5 degree steps.

The door shall be securely attached to the housing with stainless steel hardware. All access openings shall be provided with neoprene or rubber gaskets.

- (c) Optical Unit. The optical unit shall be according to ITE Standards.
  - (1) The conventional signal section shall be according to the following:
    - a. Lamp. The lamps shall be an incandescent type and a minimum 85% Krypton filled. The lamp for a 300 mm (12 inch) section shall be nominal 135 watts, 1750 lumens with a minimum average rated life of 8,000 hours (0.91 year). The lamp for a 200 mm (8 inch) section shall be nominal 60 watts, 610 lumens with a minimum average rated life of 8,000 hours (0.91 year).
    - Reflector. The reflector shall be a parabolic silvered glass or Alzak aluminum.
    - c. Dimmer. When specified on the plans, signal dimmers shall be provided for 300 mm (12 inch) yellow signal sections. The dimmer shall allow the signal lamp to operate at full intensity under daylight conditions and to reduce proportionally to 25  $\pm$  5 percent of full intensity at night. A dimmer shall not control more than one yellow section for each direction.

- (2) The optically programmed signal section shall be according to the following:
  - a. Lamp. The lamp shall be a nominal 150 watts sealed beam unit having an integral reflector and a minimum average rated life of 6,000 hours (0.68 year).
  - b. Optical Limiter-Diffuser. The optical limiter-diffuser shall provide an imaging surface at focus on the optical axis for objects 275 m to 365 m (900 to 1,200 ft.) distance and permit an optical masking tape to be variously applied as determined by the desired visibility zone. The optical limiter diffuser shall be provided with positive indexing means and composed of heat-resistant glass.
  - c. Objective Lens. The objective lens shall be a high resolution planar incremental lens hermetically sealed with a flat laminate of weather-resistant acrylic. The lens shall be symmetrical in outline and capable of being rotated to any 90 degree orientation about the optical axis. The projected signal indication shall be capable of being veiled anywhere within 15 degrees of the optical axis. The indication shall not result from external illumination and shall be according to the ITE Standards.
  - d. Photo Control. The photo control shall comprise an integrated, directional light sensing and regulating device interposed between lamp and line wires. The lamp intensity shall not be less than 37 percent of uncontrolled intensity at 10,000 lux (1,000 footcandles) and shall be reduced to 15 ± 2 percent of maximum at less than 10 lux (1 foot-candle). The response shall be proportional and essentially instantaneous to any detectable increase of illumination from darkness to 10,000 lux (1,000 foot-candles) and damped for any increase from 10,000 lux (1,000 foot-candles). The photo control shall be compatible with 60-hertz input and responsive within the range of 105 to 135 VAC.
- (d) Terminal Block. Each signal face shall contain a terminal block with at least 10 terminals.
- (e) Visor. The conventional signal section shall be furnished with a tunnel type visor, and the optically programmed signal section shall be furnished with a cutaway type visor. The visor shall be a minimum of 1.2 mm (0.05 inch) in thickness. The visor for a 200 mm (8 inch) signal section shall be a minimum of 175 mm (7 inch) in length and the visor for a 300 mm (12 inch) signal section shall be a minimum of 225 mm (9 inch) in length.
- (f) Mounting Bracket. The mounting bracket shall be made of steel or aluminum. signal heads with more than one signal face shall be furnished with terminal compartments. Each terminal compartment shall contain a terminal block with at least 16 terminals.
- (g) Finish. The aluminum signal head shall be painted according to Section 851 except the primer shall be applied to all areas. For polycarbonate signal heads, the colors specified in Section 851 shall be an integral part of the material composition.

- **1085.38 Pedestrian Signal Head.** The pedestrian signal head shall be according to the ITE Standards.
  - (a) Housing and Door. The housing and door of each section shall be according to Article 1085.37.
  - (b) Optical Unit. Each signal section shall have an optical unit according to Article 1085.37, except the lamp for a 300 mm (12 inch) section shall be nominal 90 watts, 1040 lumens with a minimum average rated life of 8,000 hours (0.91 year) and the lamp for a 225 mm (9 inch) section shall be nominal 54 watts, 530 lumens with a minimum average rated life of 8,000 hours (0.91 year). When specified on the plans, symbolic walk (walking person) and don't walk (upraised palm) indications shall be used.
  - (c) Terminal Block. Each pedestrian signal face shall contain a terminal block with at least 8 terminals.
  - (d) Visor. The visor for each signal shall be either the tunnel visor or the low profile visor. The tunnel visor shall be according to Article 1085.37

The low profile visor shall be no deeper than 50 mm (2 inches) and shall consist of louvers to provide, shade from the direct sun rays and a cutoff angle restricting the unintended viewing of the signal indication. The low profile visor shall be impregnated black polycarbonate, eliminating the deterioration of the color and texture of the visor from the exposure to the ultraviolet sun rays.

- (e) Mounting Bracket. The mounting bracket shall be according to Article 1085.37, except no terminal compartment will be required.
- (f) Finish. The aluminum pedestrian signal heads shall be according to Section 851 except the primer shall be applied to all areas. For polycarbonate pedestrian signal heads, the colors specified in Section 851 shall be an integral part of the material composition.

**1085.39 Traffic Signal Backplate.** The traffic signal backplate shall be made of sheet aluminum, sheet ABS plastic, or ABS plastic (vacuum formed). The sheet aluminum shall have a nominal thickness of 1.3 mm (0.05 inch) and shall be according to ASTM B 209, Alloy 3003-H14 or better. The sheet ABS plastic shall have a nominal thickness of 2.5 mm (0.1 inch) and shall have a minimum tensile strength of 30 MPa (4,300 psi) at 39 °C (73 °F.). The vacuum formed ABS plastic backplate shall have a nominal thickness of 3 mm (1/8 inch), a nominal 12 mm (1/2 inch) deep back flange on all inside and outside edges, and a minimum tensile strength of 30 MPa (4,300 psi) at 39 °C (73 °F.).

The backplates shall be composed of one piece. The backplate shall be designed to be attached to a signal face without interfering with the opening and closing of the traffic signal door. It shall be rectangular in shape with round corners and shall be of such dimensions as to give an exposed margin of 125 mm (5 inches) on each side. If the signal face has both 200 mm (8 inch) and 300 mm (12 inch) sections, the width shall be measured from the outside of the housing of the 300 mm (12 inch) section.

When specified the surface of the backplate shall provide openings (louvers) to allow wind to penetrate and reduce wind loading. The louver openings shall cover a minimum of 20% of the surface area of the backplate.

The aluminum backplates shall be shop painted with one coat of primer and two

coats of dull (matte) black enamel. The painting shall be according to Section 851. For the plastic backplates, the black color shall be an integral part of the material composition and shall not deteriorate under the exposure to ultraviolet sun rays.

**1085.40 Directional Louver.** The directional louver shall be made of aluminum alloy and shall have a minimum of 5 vanes.

The directional louver shall be shop painted with one coat or primer and two coats of dull (matte) black enamel. The painting and materials shall be according to Section 851.

- **1085.41 Traffic Signal Post.** The traffic signal post shall be designed to support the traffic signal loading shown on the plans. The design and fabrication shall be according to the Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals, as published by AASHTO.
  - (a) Post. The post shall be made of steel or aluminum and have an outside diameter of 115 mm (4 1/2 inches). The post shall be threaded for assembly to the base. Aluminum posts shall be according to the specifications for Schedule 80 aluminum pipe. Steel posts shall be according to the specifications for Schedule 40 steel pipe.
  - (b) Base. The base of a steel post shall be cast iron. The base of an aluminum post shall be aluminum. The base shall be threaded for the attachment to the threaded post. The base shall be approximately 375 mm (15 inches) high and 335 mm (13 1/2 inches) square at the bottom. The bottom of the base shall be designed to accept four 16 mm (5/8 inch) diameter anchor bolts evenly spaced in a 320 mm (12 1/2 inches) to 330 mm (13 inches) diameter circle. The base shall be true to pattern, with sharp clean-cutting ornamentation, and equipped with access doors for cable handling. The door shall be fastened to the base with stainless steel screws. A grounding lug shall be provided inside the base.

The aluminum post and base shall be drilled at the third points around the diameter and 6 mm (1/4 inch) by 50 mm (2 inch) stainless steel bolts shall be inserted to prevent the post from turning and wobbling.

- (c) Anchor Bolts. The anchor bolts shall be a minimum of 16 mm (5/8 inch) in diameter and 400 mm (16 inches) long and shall be according to Article 1006.09 The anchor bolts shall be threaded approximately 75 mm (3 inches) at one end and have a bend at the other end. The first 125 mm (5 inches) at the threaded end shall be galvanized. One each galvanized nut and washer shall be furnished with each anchor bolt.
- (d) Finish. The steel post and the cast iron base shall be either hot-dipped galvanized in according to AASHTO M 111 or shop painted with 1 coat of primer and 2 coats of yellow enamel according to Section 851. If the post and the base are threaded after the galvanization, the bare exposed metal shall be immediately cleaned to remove all cutting solvents and oils, and then spray painted with 2 coats of an approved galvanized paint.

## 1085.42 Pedestrian Push-Button Post.

(a) Post. The steel post shall be according to Article 1085.41, except the nominal size shall be 75 mm (3 inches). The Type I pedestrian push button post shall use a 75 mm (3 inch) threaded connection. The Type II pedestrian push-button post shall include 2 flange plates located approximately 25 mm (1 inch) above the ground level.

(b) Finish. The post and cap shall be either hot-dipped galvanized according to AASHTO M 111 or shop painted with 1 coat or primer and 2 coats of yellow enamel according to Section 851. If the post is threaded after galvanization, the bare exposed metal shall be immediately cleaned to remove all cutting solvents and oils, and then spray painted with 2 coats of an approved galvanized paint.

## 1085.43 Mast Arm Assembly and Pole.

- (a) Steel Mast Arm Assembly and Pole and Steel Combination Mast Arm Assembly and Pole. The steel mast arm assembly and pole and steel combination mast arm assembly and pole shall consist of a traffic signal mast arm, a luminaire mast arm or davit (for combination pole only), a pole, and a base, together with anchor bolts and other appurtenances. The configuration of the mast arm assembly, pole, and base shall be according to the details shown on the plans.
  - (1) Loading. the combination mast arm assembly and pole, and mast arm assembly and pole shall be designed to support one 36 kg (80 pound) signal head with a projected area of 1.37 m² (14.7 sq. ft.) at the free end of the mast arm, one 23 kg (50 pound) signal head with a projected area of 0.81 m² (8.7 sq. ft.) mounted 3.6 m (12 ft.) inward on the mast arm, one 56 kg (125 pounds) signal head with a projected area of 0.71 m² (7.6 sq. ft.) mounted 3.6 m (12 ft.) high on the shaft, and a sign panel 750 mm by 1,800 mm (2.5 ft. by 6. ft.) mounted as shown on Standard 720016 or the loading shown on the plan, whichever is greater. The design shall be according to the requirements of the current Standard Specification for Structural Supports for Highway Signs, Luminaires, and Traffic Signals as published by AASHTO for 130 km/h (80 MPH) wind velocity.
  - (2) Structural Steel Grade. The mast arm and pole shall be fabricated according to ASTM A 595, Grade A or B. The base and flange plates shall be of structural steel conforming to AASHTO M 183 or of cast steel conforming to ASTM A 27, Grade 70-36 or better. All mast arm assemblies, poles, and bases shall be galvanized according to AASHTO M 111.
  - (3) Fabrication. The design and fabrication of the mast arm assembly, pole, and base shall conform to the requirements of the Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals published by AASHTO. The mast arm and pole may be of single length or sectional design. If section design is used, the overlap shall be at least 150 percent of the maximum diameter of the overlapping section and shall be assembled in the factory.

The manufacturer will be allowed to slot the base plate in which other bolt circles may fit, providing that these slots do not offset the integrity of the pole.

(4) Shop Drawing Approval. The contractor shall submit detailed drawings showing design materials, thickness of sections, weld sizes, and anchor bolts to the Engineer for approval prior to fabrication. These drawings shall be at least 430 mm by 560 mm (17 inches by 22 inches) in size and of adequate quality for microfilming. (b) Anchor Bolts. The anchor bolts shall be according to Article 1006.09 and shall be threaded a minimum of 185 mm (7 1/2 inches) at one end and have a bend at the other end. The first 250 mm (10 inches) at the threaded end shall be galvanized. Two nuts, one lock washer, and one flat washer shall be furnished with each anchor bolt. All nuts and washers shall be galvanized.

# 1085.44 Traffic Signal Wood Pole.

- (a) Pole. Wood pole shall be full-treated southern pine, Douglas fir, or western red cedar conforming to the American National Standard Specifications and Dimensions for Wood Poles. The preservative treatment shall conform to the American Wood Preservers' Association Standard C4.
- (b) Down Guy. The down guy shall consist of a guy wire and other appurtenances as shown on the plans. The guy wire shall be of 9.5 mm (3/8 in.) nominal diameter 7-strand, zinc-coated steel wire conforming to ASTM A475, Utilities Grade or better. The other appurtenances shall be galvanized according to AASHTO M 232 and be according to the following:

The anchor shall have a minimum expanded area of 81,000 mm<sup>2</sup> (125 sq. inches).

The anchor rod shall have a nominal diameter of 16 mm (5/8 inch) and a minimum breaking strength of 51,200 N (11,500 lbs.).

The guy guard shall be 2.5 m (7 ft.) long, tapered, and made of 18-gauge steel minimum, except for sidewalk guys, the guy guards shall be made of heavy-duty plastic.

The guy wire clamps shall be 3-bolt and have a minimum breaking strength of 51,200 N (11,500 lbs.).

The dead-ends shall be made of the same material as the guy wire.

- **1085.45** Traffic Actuated Solid State Digital Controller. A traffic actuated solid state digital controller shall be according to NEMA Standards for Traffic Control Systems, TS 1. Additionally, the controller shall be of digital design having 8 independent phases and 4 overlap phases and shall be according to the following:
  - (a) Definitions.
    - (1) Anti-backup. A programmable controller logic function inhibiting a call on a leading left turn phase (1, 3, 5 or 7) from being served prior to crossing the barrier if the opposing through phase (2, 4, 6, or 8) is on, and thus avoiding left turn trap.
    - (2) Minimum Red Indication (Red Revert). Provision within the controller to assure a minimum RED signal indication in a phase following the YELLOW CHANGE interval of that phase.
    - (3) Offset. The time relationship expressed in seconds or percent of cycle length, determined by the difference between the starting point of the coordinated phase green and a system reference point.
    - (4) Phase. The green, change, and clearance intervals in a cycle

assigned to any independent movement(s) of traffic.

# (b) Design.

- (1) Menu Driven Programming. The controller programming software shall utilize a menu structure displayed on a screen. The software shall display on 1 screen any phase associated parameter for all 8 independent phases. The controller shall be capable of being programmed from the front key panel.
- (2) Electrically Erasable Programmable Read Only Memory (EEPROM) Data Storage. All controller programming data shall be retained utilizing EEPROM technology.
- (3) RS 232 Connector. The controller shall be provided with a RS 232 connector to interface with a peripheral device.
- (4) Internal Time Base Coordination. The controller unit shall have internal time base coordination as specified in Article 1085.45.
- (5) Internal Preemption Feature. The controller unit shall preempt the signal according to Article 1085.45.

# (c) Functions.

(1) Internal Time Base Coordination.

The controller shall contain a sufficient memory to retain and implement the following programs and shall be manually programmable by a user from the front panel:

- At least 4 cycle lengths, 4 splits, and 3 offsets.
- b. 16 day programs.
- c. 10 week programs.
- d. 30 special event programs.
- e. Automatic daylight savings and leap year adjustments.

The controller shall contain a calendar/clock that can be readily set to the nearest week, day, hour, minute, and second of the year. The clock shall use the power line frequency as a time base, and shall use a rechargeable battery powered, temperature compensated oscillator when power is interrupted. The capacity of the battery shall be sufficient to provide 100 consecutive hours of standby operation after 48 hours of normal operation. The clock accuracy shall be 0.005% or better when it is on standby power.

The controller shall provide a split interval for every phase of the controller. Phase split time shall be entered directly in percent of cycle length or in seconds. The yield and force-off points shall be calculated automatically.

The controller shall have the capability to omit any phase during any program. this feature shall be internal to the controller and shall be

selectable by the user from the front panel.

The offset reference point shall be at the beginning of the coordinated phase green. The offsets shall be in seconds or percent of cycle length and shall be calculated automatically when the cycle length is changed.

The controller shall have built-in diagnostics to detect both coordination and hardware failures. In case the coordination is not functioning, the controller shall revert to the free operation mode.

The controller shall provide real time display of its stored coordination information. The display shall be easily readable outdoors. The controller shall display the following data:

Coordination parameters.

Clock data (week of year, day of week, hour, minute, and second). Current operational status.

The controller shall upload and download the complete coordination settings.

- (2) Internal Preemption Feature. The controller shall implement up to 6 preemption plans according to a preset priority. The method of activation used in preemption shall be equipped with a fail-safe feature.
- (3) The controller shall have the following features.

The controller program shall include the option of single entry or dual entry mode of operation.

The overlap phases shall be programmable from the front panel or by a method approved by the Engineer.

The controller shall cross switch detectors from a left-turn phase to an associated through phase according to NEMA dual ring operation.

The controller shall interface internally with the transceiver of the same manufacture.

The controller program shall include an anti-backup feature.

The controller shall have a programmable minimum RED indication (red-revert) feature of up to 9.9 seconds.

- **1085.46 Master Controller.** A master controller shall be microprocessor based and shall be according to NEMA Standards for Traffic Control Systems, (TS 1) and the following:
  - (a) Operation Modes. The master controller shall be capable of operating in any of the following modes:
    - Traffic Responsive. Pattern selection shall be based on traffic conditions measured by system detectors.
    - (2) Time-of-Day/Day-of Week. Preprogrammed selection of patterns shall

be based on time-of-day/day-of-week.

(3) Manual. Pattern selection shall be based on operator command.

## (b) Design

- (1) Transceiver. The master controller shall contain a transceiver which shall provide transmission of all required pattern and command data to the local intersection controllers and shall allow reception of status and detector data from each local controller within the control area. The data rate among the master controller and the local controllers shall be 1200 baud minimum.
- (2) In-Cabinet Modem. The controller cabinet shall contain a 2400 baud auto dial/auto answer modem. It shall accept Attention (AT) command set. The data rate shall be 2400 baud minimum.
- (3) Telephone Line Terminal. The controller cabinet shall be provided with an outdoor network interface for the termination of the telephone service. It shall be mounted to the inside of the cabinet suitable to provide access for the termination of the telephone service and shall be equipped with a standard three-electrode heavy-duty gas tube surge arrestor.
- (4) Surge Protection. The controller cabinet shall be equipped with surge suppressers and noise filters for the telephone line and the modem's power receptacle. These shall be 3 stage variety containing avalanche diodes, metal-oxide varistors and gas tube arrestors.
- (5) RS-232 C Interface. The master controller shall be equipped with 2 RS-232C interfaces for external communication with a remote personal computer and with a local device such as a portable personal computer or a printer.
- (6) Keypad Data Entry and Front Panel Display. The master controller shall be programmable via a front keypad entry. A front panel display shall be provided on the master controller for operator monitoring of input values and output commands including:

Parameter values
Current operating status
Pattern command status
System sensor activity
Cycle synchronization
Local controllers and system detectors operation status

### (c) Functions.

- (1) Operational Capacity
  - Number of Local Controllers. The master controller shall have the capacity to command and supervise a minimum of 24 local controllers.
  - b. Number of System Detectors. The master controller shall have the capacity to monitor at least 32 sampling detectors for all controlled intersections and up to 16 sampling detectors for a single intersection. The detectors used as sampling detectors shall be selectable from dedicated sampling detectors or local

intersection detectors in any combination.

- c. Number of Timing Plans and System Commands. The master controller shall be capable of implementing a minimum of 30 timing plans. Each plan shall consist of a combination of cycle length, offset, and split. The master controller shall be capable of a minimum of four system commands including the commands for controller free or coordinated operation and for controller MUTCD flash operation.
- d. Number of Program Events. The master controller shall be capable of providing a minimum of 150 program events. A program event shall consist of a selected time of day, day of the week, and week of the year for which a timing plan, out of a minimum of 30 timing plans, shall be put into effect.
- e. Number of Logged Events. The master controller shall be capable of logging a minimum of 100 events under the buffer(s) with a time and date stamp for each event. This data shall be stored in the master controller and retrievable through the remote monitoring microcomputer.
- (2) Operation Modes.
  - Traffic Responsive Operation. Pattern selection shall be based on user-selectable validated volume, occupancy, or concentration data obtained from system detectors to compute the following functions:

Level of arterial traffic
Directionality of arterial traffic
Ratio of a set of detectors to a second set of detectors
Ratio of side street to arterial traffic

Preferential and/or hierarchical transfer of patterns shall be accomplished via programmable user-specified threshold values.

b. Time-of-Day/Day-of-Week Operation. The master controller shall be according to the internal time base coordination as specified in Article 1085.45. It shall be possible to select any system pattern from the master controller on a preprogrammed time-of-day/day-of-week basis with automatic daylight savings and leap year adjustments. In addition, it shall be possible to specify the following on a time-of-day/day-of-week basis:

> Special function system commands Crossing artery synchronization Traffic responsive computation period System detector and speed report interval

- Manual Operation. Pattern selection shall be based on operator command.
- (3) Remote System Controlling, Reporting, Monitoring, and Diagnosing.

The master controller shall be capable of being programmed and monitored from a remote site through a computer program running

under Microsoft Disk Operating System (MS DOS<sup>TM</sup>) or under Windows Operating System on a IBM personal computer or a compatible machine either stand-alone or a station in a local area network (LAN). The IBM PC or a compatible shall utilize a 486 series microprocessor or a next generation of microprocessor. The programming and monitoring from the remote site shall include the following functions:

- Remote System Control. The master controller shall enable upload and download of all master programming as well as local controller programming.
- b. Remote System Reporting.
  - System Status Report. When requested a system status report shall be generated. The report shall indicate current operating mode and pattern for local controllers.
  - System Failure Report. This report shall indicate the off line local controllers and the failure time and mode. The master controller shall communicate the local controller faults to the remote site.
  - 3. System Detector Failure Report. All failed system detectors shall be listed on this report.
  - System Detector Report. The volume and occupancy data from any of the system detectors, tabulated by 15-minute intervals for a 24 hour period shall be included on this report.
  - System Fault Alarms. The master controller shall have the capability of programmable fault reporting by dialing out to assigned telephone number(s). A minimum of 3 levels of programmable alarms shall be provided.
  - System Operation Report. This report or an equivalent shall indicate the time of changes in operation mode and the timing patterns for the past 48 hours.
- c. Remote System Monitoring.
  - Number of Systems Monitored. The remote system software shall be capable of monitoring a minimum of 99 separate systems.
  - 2. Data Compatibility Between the Software Versions. Data from earlier versions of the remote system monitor software shall be compatible with or easily translatable for use in newer version upgrade. Manual reconstruction of data base shall not be required with each upgrade. All software located in controllers and master controllers, which are currently in use in the field and new, shall be compatible with all current or new versions of the remote system monitor software. The version of the software for all master and local controllers shall be uploaded and viewed during each upload and download. As part of a data base set up, the remote system monitor software shall not require master and local controller software versions to be manually programmed

except for the master and local controller model numbers or types. All firmware changes made at any master or local controller shall be transparent to the remote system monitor software.

3. Intersection and System Graphics. The supplier of the master controller shall create intersection and system graphic displays and program all software parameters for each intersection to be monitored through the master controller, including complete viewing and control capabilities. Each intersection display and system display shall show a mode of operation, that is, traffic responsive, time of day, or free, and the timing plan in effect for the coordinated operation, that is, cycle length, split, and offset.

The intersection displays shall be an accurate graphical representation of the intersection geometry, lane configuration, signal phasing, and detector layout. The display shall contain the correct alignment of the crossing streets and include the correct number and types of lanes. Depending on the intersection geometry, the display shall show left turn lanes, dual left turn lanes, multiple through lanes, and right turn lanes. The display shall contain indicators for all used controller phases, associated pedestrian phases, and overlap phases, and for local detectors actuation, and system detectors actuation.

The system displays shall be an accurate graphical representation of the signal system. The system display shall contain all system intersections. The display shall contain indicators for all used phases at all intersections and system detectors actuation.

# d. System Diagnostics.

- Local Controller Diagnostic. At a minimum the master controller shall diagnose and report local controller flash fault by reporting the conflict monitor fault logging information for the current fault.
- 2. System Detector Diagnostic. Each system detector shall be monitored for constant calls, absence of calls, or erratic output. Diagnostic values shall be user programmable for all detectors on a system basis. System detectors which fail the diagnostic test shall be automatically deleted for volume and occupancy calculations. The event of failure occurrence shall be stored for reporting. Upon resumption of satisfactory operation, detectors shall automatically resume input to volume and occupancy calculations.

## 1085.47 Controller Cabinet And Peripheral Equipment.

(a) Cabinet. A controller cabinet shall house a controller and peripheral equipment by providing a secure space and by guarding against inclement weather. The cabinet shall be made of an aluminum alloy and shall be of sturdy construction. Only one cabinet shall be permitted at one intersection for all traffic control equipment.

(1) Cabinet Type. The cabinet specified on the plans shall be determined on the basis of the average volume of the control equipment to be installed in the cabinet. The various types of cabinets shall meet the following:

Туре	Approx.	Volume	Police	Mounting	Ventilation	Remark	
	$m^3$	(ft. <sup>3</sup> )	Door				
1	Reserve	Reserved					
II	0.14	(5.0)	Yes	Post Top	Filtered Air Intake and One Thermo- statically Controlled Fan		
III	0.33	(11.5)	Yes	Ground Mount	Filtered Air Intake and One Thermo- statically Controlled Fan	For Traffic Actuated Controller	
IV	0.82	(29.0)	Yes	Ground Mount	Filtered Air Intake and Two Thermo- statically Controlled Fans	For Traffic Actuated Controller. Back Panel with Minimum 12 Load Switch Positions.	
V	1.25	(44.0)	Yes	Ground Mount	Filtered Air Intake and Two Thermo- statically Controlled Fans	For Traffic Actuated Controller. Back Panel with Minimum 12 Load Switch Positions.	

## (2) Weather Resistant Requirements.

- Heavy-duty Door Gasket. Heavy-duty gaskets shall be provided around door openings to make a weather-tight seal for the protection of the enclosed equipment.
- b. Caulking of Cabinets. Ground mount cabinets shall be caulked along the entire perimeter of the base with a waterproof, nonhardening exterior compound prior to setting on the foundation to ensure a water, dust and insect-proof seal.
- c. Screened Vent. A standard furnace filter shall be mounted on the inside of the cabinet door and shall be designed to prevent the entrance of insects, blowing rain and snow. It shall be securely attached to the cabinet and shall be removable by simple tools to permit cleaning and replacement.
- d. Cabinet Exterior. The cabinet surface shall be smooth, free of marks and scratches and provide an unpainted aluminum finish.
- (3) Cabinet Design.

- a. Multiple Door-Stop. The cabinet front door shall be capable of being held at various angles by a stop-and-catch mechanism.
- b. Door Handle. The door handle shall rotate outward from the locked position. The operation of the handle shall not interfere with the key, police door or any other cabinet mechanism.
- c. Door Locks and Keys. The front door shall be equipped with a standard or a tumbler lock and the police door shall be provided with a police type lock. The front door lock shall not open by a standard police key. Additionally, two sets of keys shall be provided with each cabinet.
- (4) Lightning Protection. The cabinet shall be provided with lightning protection. Lightning arrester leads should be kept as short as possible and ground should be made directly to the cabinet wall or ground plate as near as possible to the object being grounded. All lightning arresters shall be tested and certified as meeting this specification by an independent testing laboratory. One copy each of the full testing report shall be submitted to the Engineer.
  - a. AC Input for Solid State Controller. The arrester shall be capable of withstanding a minimum of 10 repeated 20,000-ampere (8 x 20 microsecond wave form) surges, and shall have initial follow current limiters (resistive elements), a series filter network (rated 10 amperes), and a high speed clamping component. The inductance shall be a minimum of 200 microhenries and the high speed clamp shall have a maximum response time of 5 nanoseconds. The maximum clamp voltage shall be 380 volts at 20,000 amperes.
  - b. Detector Loop. The shield and the drain wire of the lead-in cable shall be grounded at the controller cabinet end to the closest cabinet wall or ground plate. At the other end, the shield and the drain wire shall be insulated to prevent possible grounding.
  - Interconnection, 120 VAC. A replaceable spark gap gas type cartridge shall be provided between each incorming conductor and ground.
  - d. Interconnection, DC or Low Voltage Balanced Line. The unit shall be capable of withstanding a minimum of 100 repeated 2,000 ampere (8 x 20 microsecond wave form) surges. The response time shall not exceed 100 nanoseconds with a duty cycle of 0.01 percent for 100-ampere surge. The voltage clamp shall be 30 volts.
- (5) Miscellaneous Cabinet Function Requirements.
  - Signal Flash in Absence of Conflict Monitor. The cabinet shall contain circuitry that will place signal into flashing mode of operation if the conflict monitor is disconnected.
  - b. Thermostatically Controlled Exhaust Fan. The cabinet shall be equipped with a thermostatically controlled exhaust fan. The fan shall have a minimum air delivery capacity of 2.8 m² (100 cu. ft.) per minute and shall be mounted on self-lubricating ball bearings. The thermostat control shall be adjustable between 33 °C

(91 °F.) and 45 °C (113 °F.) and shall be set to turn the fan on at 35 °C (95 °F.).

- c. Power Outlet and Light Fixture. Within the cabinet shall be provided a grounded three-wire, 120 volt, ground fault interrupter duplex outlet and a cabinet-door-switchable light fixture with a standard incandescent soft light bulb of 55 to 70 watts.
- d. Signal Control Switches. The switches shall be provided in the controller cabinet for the following mode of operation:

Controller: ON-OFF

Controller: STOP TIME-RUN-REMOTE

Signals: NORMAL-MUTCD FLASH (with controller on)

The switches shall be provided in the police door compartment for the following mode of operation:

Signals: ON-OFF (The switch operation shall not depend

on the position of AUTO-FLASH switch.)
Signals: AUTO-FLASH (with controller in stop time)

Signals: AUTO-MANUAL

# (b) Peripheral Equipment.

- (1) Conflict Monitor. A conflict monitor shall be according to NEMA Standards for Traffic Control Systems, TS 1, including the specified monitoring of signal indication conflict, absence of RED signal voltage, and voltage. The conflict monitor shall be according to the following:
  - a. Number of Programmable Channels. The conflict monitor shall have either 12 or 18 fully programmable channels according to NEMA Type 12 or Type 18 unit respectively. The number of channels shall be sufficient to monitor all of the used vehicular phases, associated pedestrian phases, and overlap phases.
  - b. Simultaneous Dual Color Conflict. The conflict monitor shall detect simultaneous display of 2 separate colors in each signal face except the simultaneous display of "circular red" and "green turn arrow", or "circular red" and "yellow turn arrow" as signal indication conflict.
  - c. Operation Upon Conflict Detection. Upon detection of signal indication conflict, absence of RED signal voltage or specified voltage deviation, the monitor shall place the signals into emergency flashing operation. The controller shall stop timing in the condition that existed at the moment of conflict and shall remain in stop time, except for the emergency flash caused by specified voltage deviation, until reset by maintenance personnel. The monitor channel indicators shall display the fault status and the field output status at the time of the failure.
  - d. Fault Log. The conflict monitor shall store a minimum of last 20 fault status and the corresponding field output status with the date and time stamps in a non-volatile memory.
  - e. Liquid Crystal Display (LCD). The conflict monitor shall

simultaneously indicate the field output status for all the programmed channels on the LCD. When interrogated, the conflict monitor shall indicate the stored fault status on the LCD.

- f. Channel to Phase Association. The conflict monitor channels shall be assigned the same channel numbers as the phase they are monitoring.
- (2) Load Switches. All signal lamp circuits shall be opened and closed by solid state load switches according to NEMA Standards for Traffic Control Systems, TS 1. Load switches shall have a rated load capacity of 15 amperes minimum within the temperature range of -34 °C (-29 °F.) and 74 °C (165 °F.). A sufficient number of load switches shall be furnished with each controller so the maximum load per circuit will not exceed 900 watts. The load switches shall be provided with LED indicator lights to indicate the controller output status.
- (3) Panel and Terminal Facilities. Panel and terminal facilities shall be according to NEMA Standards for Traffic Control Systems, TS 1. Additionally, the panel and terminal facilities shall be according to the following:

The panel board shall be provided on the back wall of the controller cabinet containing local switch sockets and terminal facilities. The load switch sockets shall be positioned so as to accept various NEMA load switches with different sizes of heat sink housings.

The back panel for the cabinet Types IV and V shall contain at a minimum: 12 load switch wired sockets and 4 flash transfer relay wired sockets. To prevent the conflict monitor from detecting absence of RED voltage on the spare wired sockets, the RED output pin (pin 1) shall be wire jumpered to 120 VAC (pin 3).

One circuit breaker rated 10 amperes shall be provided for the control equipment and another circuit breaker rated 40 amperes shall be provided for the signal load.

The field wire terminals shall be located at least 250 mm (10 inch) above the bottom of the controller cabinet.

(4) Flasher Unit and Flasher Relay. A flasher unit shall be according to NEMA Standards for Traffic Control Systems TS 1, for NEMA Type 3 Flashers, (15 amperes, dual-circuit) and the following:

Each controller shall be provided with one or more jack-mounted flasher units and the necessary relays. The flasher and flasher relay shall not operate at more than 85 percent of its rated load.

In conflict monitor triggered flash, all three-color signal indications shall flash in red, all signals controlling the same approach of an intersection shall flash simultaneously, and the pedestrian signal faces shall be dark.

Automatic changes from stop-and-go to flashing operation and vice versa shall begin at a predetermined interval according to the MUTCD, Section 4B-18.

It shall be possible to remove the controller and its associated components from the cabinet with the flasher continuing in operation.

**1085.48 Inductive Loop Detector.** The inductive loop detector shall be according to the NEMA Standards for Traffic Control Systems, TS 1 and the following:

# (a) Functions.

The inductive loop detector shall have a minimum of 7 levels of sensitivity control and shall be of sufficient sensitivity to detect the smallest licensable motor vehicle, including motorbikes.

The inductive loop detector shall have a minimum of 2 modes of operation - presence or pulse.

The inductive loop detector shall be capable of self-tuning.

The inductive loop detector shall, in a failure condition, register a continuous call to the signal controller.

Extend Call - Delay Call. The inductive loop detector shall change from delay mode to extend mode and vice versa at the end of the time set for each mode. The inductive loop detector shall have a means of visually indicating the timings of delay and extension settings are in effect.

(b) Special Feature.

System Output. In addition to supplying normal timing output, the detector shall be capable of providing a simultaneous system output for traffic volume, occupancy, and speed measuring. The system output shall be constant and not affected by delay or extension timings. This output shall allow either presence or pulse operation which may be selectable from a front panel switch. The presence and pulse outputs shall be according to NEMA. When required, this feature shall be internal to the detector.

**1085.49 Transceiver.** A transceiver shall be microprocessor based and shall be according to NEMA Standards for Traffic Control Systems, TS 1 and the following:

(a) Design. The transceiver shall provide the following:

Frequency shift keying or time division multiplexing techniques. Half duplex or full duplex communications. Parity and error checking diagnostics to assure transmission and reception of valid data at 1200 baud minimum. Keyboard entry of system address from the front panel. Transmitter frequency stability over the NEMA operating temperature range of  $\pm$  5 Hz.

- (b) Functions.
  - (1) The transceiver shall be capable to receive the following command data from a master controller and convey them to the local controller:

Cycle lengths, offsets and splits Special functions Coordinated or free mode A systemwide sync (2) The transceiver shall monitor the status of the following functions and transmit the information to a master controller:

Local controller phase green
Local coordinator operation
Conflict Flash
Manual flash
Preemption
System detectors (a minimum of four) and local
detectors (a minimum of eight)

- (3) The transceiver shall allow downloading and uploading of the local intersection data base. The preemptor and overlap data will not be downloaded.
- (c) Housing. The transceiver may be integral to the controller or furnished as a separate module in the controller.

## 1085.50 Flasher Controller.

- (a) Flasher. The flasher shall be NEMA type 3 and be according to NEMA Standards for Traffic Control Systems, TS 1. LED indictors shall be provided to track the flasher output.
- (b) Housing. The flasher shall be enclosed in a weatherproof, cast aluminum cabinet of adequate size. A 15-ampere circuit breaker shall be provided for the incoming power line.

### 1085.51 Pedestrian Push-Button.

- (a) Housing. The housing shall be made of aluminum alloy and furnished with suitable mounting hardware. The front of the housing shall have flexible cover so the push-button detector will be freezeproof.
- (b) Push-button. The push-button shall be made of brass or other nonrusting material and shall be of sturdy design.
- (c) Contacts. The contacts shall be entirely enclosed and insulated from the push-button housing. The contacts shall be normally open and shall be closed when the push-button is pressed, restoring immediately to a normal open position when released.
- (d) Sign. The pedestrian information sign shall be according to the MUTCD. The legend on the sign shall either be all words or a combination of words and symbol to match the pedestrian signal. The sign base shall be sheet aluminum according to Artlce 1090.01.

## 1085.52 Detector Loop.

(a) Wire. Type I detector loop wire and the loose encasing shall be according to IMSA 51-5.

Type II detector loop wire shall be No. 16 AWG, mineral-insulated, copper sheathed cable. The conductor shall be insulated with magnesium oxide and enclosed in a seamless copper sheath with a polyethylene jacket. A terminal subassembly kit composed of a pot, cap, sealer, and sleeves shall be supplied with the cable.

Type III detector loop wire shall be No. 14 AWG, Type THWN or THHN with stranded copper conductor. The rigid plastic conduit shall be 12 mm (1/2 inch) schedule 80 PVC or polypropylene conduit. All bends shall be a 150 mm (6 inch) radius minimum and shall be integral to the conduit.

- (b) Sealer. The Sealer for Type I detector loop shall be one of the following:
  - (1) Polyurethane or Two-Component Polyurethane Modified Asphalt. The material shall be cured to be rubber-like, and suitable for sealing detector loops in both bituminous and concrete pavements. The cured material shall be highly resistant to oil, gasoline, salts, acids, and alkalis.
  - (2) Two-Component Epoxy or Two-Component Polyester Resin. The material shall be cured to be flexible, and suitable for sealing detector loops in both bituminous and concrete pavements. The cured material shall be highly resistant to oil, gasoline, salts, acids, and alkalis.

The above material shall have the following properties:

Pot life at 25 °C (77 °F.) 13 minutes minimum Cure Time 4 hours maximum Shore D Hardness 28 minimum

## 1085.53 Electric Cable - Signal, Lead-in, Communication, and Service.

- (a) Signal Cable. The signal cable shall transmit 120 VAC to signal heads, pedestrian heads and internally illuminated signs, or transmit 24 VDC to pedestrian push-buttons. The signal cable shall be according to IMSA No. 19-1 or IMSA 20-2. The tracer color lines shall be extruded with the insulation extrusion. The conductors shall be copper, solid or stranded, and No. 12 or 14 AWG.
- (b) Lead-in Cable Single-Pair. The lead-in cable single-pair shall transmit and receive the vehicle detection signal between the loop detector unit and the detector loop. The lead-in cable single-pair shall be according to IMSA No. 50-2. The conductors shall be stranded tinned copper, and No. 14, 16 or 18 AWG.
- (c) Communication Cable and Lead-in Cable Multipair
  - (1) Conductors. The fully annealed tinned copper shall be according to ASTM B-33. The stranded conductors shall be according to ASTM B-8 for concentric stranding or ASTM B-174 for bunch stranding. The conductors shall be No. 16 or 18 AWG, 3, 6, 9 or 12 pair.
  - (2) Insulation. The polyethylene insulation shall be according to ASTM D-1248, Type 1, Grade 4, Class A or B. The minimum insulation thickness at any point shall not be less than 90 percent of average insulation thickness of 0.51 mm (20 mils).
    - Conductor Insulation Color Code. All pairs shall have 1 conductor with black color insulation and 1 conductor with insulation of another unique non-black color.
  - (3) Shielding. The conductors shall be in twisted pairs and each pair shall be individually shielded. The shielding shall be aluminized mylar or polyester. One stranded tinned copper drain wire shall be provided.

The shielding shall be 100 percent effective by providing a metal-to-metal contact between adjacent wraps. The capacitance measured between conductors shall be 100 (30) picofarads or less per meter (foot). The capacitance measured between one conductor and another conductor connected to the shield shall be 180 (55) picofarads or less per meter (foot)

- (4) Jacket. The jacket shall be polyvinyl chloride according to IMSA No. 39-2.
- (5) Identification. Each shipping length of cable shall show the name of the manufacturer, the year of manufacture, the voltage rating, the U.L. listing mark, and the conductor size in AWG. This information shall be applied every 0.61 m (2 feet) or less to the outer surface of the jacket by indent printing. The electric cables furnished shall not be dated more than 5 years prior to the time of installation.
- (6) Sampling, inspection and acceptance. The cable shall be according to IMSA No. 39-2.
- (d) Service Cable. The stranded copper, cross-linked polyethylene insulated service cable shall be according to Articles 1085.25 and 1085.26.

# 1085.54 Fiber Optic Cable.

- (a) General. The outside plant, all-dielectric, loose-tube fiber optic cable shall be according to the ANSI, Electronics Industries Association (EIA) and Telecommunications Industries Association (TIA) for the multimode cable of the size specified, and the following:
- (b) Fiber. Each fiber shall be multimode, graded index, and a specified nominal diameter (core/clad). Each fiber attenuation shall not exceed 3.5 dB/km nominal, measured at room temperature at 850 nm and the bandwidth shall be a minimum of 160 MHz/km at 850 nm. The fibers and the buffered tubes containing loose fibers shall be color coded according to the following industry standard color coding scheme.

Color	Fiber No./	Color
	Tube No.	
Blue	7	Red
Orange	8	Black
Green	9	Yellow
Brown	10	Violet
Slate	11	Rose
White	12	Aqua
	Blue Orange Green Brown Slate	Tube No. Blue 7 Orange 8 Green 9 Brown 10 Slate 11

- (c) Cable Construction.
  - (1) Central Member. The central member of the cable shall be a glass reinforced plastic rod designed to prevent buckling of the cable.
  - (2) Fillers. Dielectric fillers may be included in the cable core where needed to lend symmetry to the cable cross-section.
  - (3) Buffer Tube Gel. Each buffer tube shall be filled with a non-hygroscopic, non-nutritive to fungus, electrically non-conductive, homogeneous gel. The gel shall be free from dirt and foreign matter and be readily removable with conventional non toxic solvents.

- (4) Cable Core Gel. In addition to the buffer tube gel properties the gel filling the cable core interstices shall be water-blocking.
- (5) Ripcord. The cable shall contain at least one ripcord under the jacket.
- (6) Tensile Strength Member. The cable tensile strength shall be provided by high tensile strength aramid yarns.
- (7) Cable Jacket. The cable shall be sheathed with medium density polyethylene. The polyethylene jacket shall be a consistent thickness having a minimum acceptable average thickness of 1.4 mm (.056 inch). The polyethylene shall contain carbon black to provide ultraviolet light protection and shall not promote the growth of fungus.
- (8) Cable Marking. The cable jacket or sheath shall be marked with the manufactuer's name, the words "Optical Cable", year of manufacture, and with sequential meter (foot) marks.
- (d) Tensile Load. The cable shall withstand a maximum pulling tension of 2700 N (600 lbs.) during installation, short term and 600 N (135 lbs.) upon installation, long term.
- (e) Temperature Range. The shipping, storing, installing, and operating range of the cable shall be -30 to 70 °C (-22 to 158 °F.).
- (f) Cable Performance Tests. The cable shall be according to the standard Fiber Optic Test Procedure for the following performance measures.

Fluid Penetration
Compound Drip
Compressive Loading Resistance
Cyclic Flexing
Cyclic Impact
Tensile Loading and Bending

- (g) Quality Assurance.
  - (1) Proof Tested. Each optical fiber shall be proof tested by the fiber manufacturer at a minimum stress of 350 MPa (50 kips/sq. inch).
  - (2) Attenuation Tested. Each optical fiber shall be 100 percent attenuation tested by the cable manufacturer and the attenuation of each fiber shall be provided with each cable reel.
- (h) Packaging.
  - (1) Cable Ends. The top and bottom ends of the cable shall be available for testing. The cable ends shall be sealed to prevent moisture ingress.
  - (2) Cable Label. Each cable reel shall have a durable weatherproof label which shows the actual length of the cable on the reel and the attenuation of each fiber expressed in dB/km.
- **1085.55 Digital Time Switch.** The digital time switch shall be according to Section 2 and Article 4.2.2 of NEMA Standards for Traffic Control Systems, TS 1, and the following:
  - (a) Functions. The digital time switch shall be capable of opening and closing

a circuit at specific times of a day and shall be capable of omitting circuit operation during certain days of the week. It shall be possible to set any opening or closing to the nearest minute, the open period for as short as 90 minutes and the close period for as short as 30 minutes. It shall also be capable of providing 4 "on" and 4 "off" operations in each 24-hour period. All settings shall be field programmable using a key pad.

(b) Designs. The digital time switch shall contain a precise clock based on a 7-day program, setable to the nearest second of the week, day, hour, and minute. The 60 Hertz power line frequency shall be the basic time reference for the clock. The clock shall automatically adjust for daylight savings and leap years.

The digital time switch shall have a battery back-up feature to protect against loss of timing in case of a power failure. During power failure, the battery operation shall keep the unit in time for a period of up to 100 hours. The unit clock accuracy shall be 0.005 percent or better when it is on battery power and shall assume normal operation upon resumption of power.

- (c) Special Features. The digital time switch shall include the following light emitting diodes indicators to confirm the applicable status outputs:
  - (1) ON OFF.
  - (2) LINE POWER BATTERY.

A time of day display shall be provided which is easily readable outdoors. Each unit furnished shall be labeled as to the function it controls.

# 1085.56 Illuminated Sign.

- (a) Housing. The housing of the illuminated sign shall be made of aluminum alloy with a minimum thickness of 1.55 mm (0.063 inch). The housing interior shall be unpainted for the fiber-optic sign and painted white for the fluorescent sign. The housing exterior shall be shop painted with one coat of primer and two coats of yellow enamel. The painting shall be according to Section 851.
- (b) Sign Face. The sign face shall be of Plexiglass or other plastic material with equivalent or better weathering, structural, and optical properties and shall be 3.1 mm (1/8 inch) ± 10 percent in thickness, 600 mm (24 inches) in horizontal dimension and 750 mm (30 inches) in vertical dimension. Colors of the legend and background and letters used in the legend shall conform to the MUTCD. The sign face shall be of the blank-out type, to be completely illegible when the sign is not illuminated.
- (c) Illumination. The fluorescent sign shall be illuminated by 8 F24-T12-CW/HO flurescent lamps. The ballasts shall be the rapid-start type.

The fiber-optic sign shall consist of fiber-optic glass bundles arranged to define the required message. The glass bundles shall be ground smooth and optically polished at the input and output ends for maximum light transmission. The output ends of the fiber-optic glass bundles that form the sign message shall be terminated using glass lenses or glass end caps.

The fiber-optic sign shall control the lamp intensity utilizing the photo control according to Article 1085.37. The lamp intensity control device shall be wired in series with the step-down transformers in the sign, on the input (120 VAC) side of the transformer. The lamp intensity control device shall be mounted in the bottom of the sign housing. Each fiber-optic sign shall have a separate lamp intensity control device.

The lamps shall have a rated minimum life of 5,000 hours.

(d) Mounting Bracket. The mounting bracket shall be according to Article 1085.37, except no terminal compartment will be required.

# 1085.57 Span Wire and Tether Wire.

- (a) Wire. The span wire shall be 9 mm (3/8 inch) nominal diameter, 7-strand, zinc-coated steel wire according to ASTM A 475, Utilities Grade or better. The tether wire shall be 6 mm (1/4 inch) nominal diameter, 7-strand, zinc-coated steel wire according to ASTM A 475, High Strength Grade or better.
- (b) Accessories. All accessories, except cable hangers, shall be made of galvanized steel or noncorrosive material. Cable hangers shall be made of exterior black nylon or steel. The tensile strength of all accessories, except cable hangers, shall be equal to or greater than the tensile strength of the wire with which they are used. Thimble-eye bolts shall be 15 mm (5/8 inch) in nominal diameter and be according to ASTM A 307.

## 1085.58 Electrical Service Installation.

- (a) Weatherhead. The weatherhead shall be designed to fit 25 mm (1 inch) threaded conduit, and galvanized according to AASHTO M 232. It shall be furnished with a composition cover with holes for service.
- (b) Circuit Breaker and Weatherproof Enclosure. The circuit breaker shall be single pole, rated 50-ampere, and mounted on an aluminum plate. The circuit breaker shall be contained in the stainless steel, weatherproof NEMA 4X enclosure of adequate size. The top and bottom of the enclosure shall be furnished with hubs for installing conduits. The enclosure shall be furnished with two padlocks for the handle and for the door when used in a Type A service installation. Each padlock shall be furnished with two No. 399 keyed alike keys.
- (c) Ground Rod. The ground rod shall be a copper clad steel solid circular cross section with a nominal diameter of 18 mm (3/4 inch) and provide a minimum cumulative in-soil-contact length of 2.4 m (8 ft.).

The ground rod shall be installed so the acute angle between the rod and the vertical line is not greater than 45 degrees. If a subsurface condition prohibits the installation of the ground rod to the required length, then several ground rods may be installed and bonded to provide a minimum cumulative in-soil-contact length of 2.4 m (8 ft.).

A ground clamp capable of accommodating a No. 6 bare copper wire shall be furnished with the rod.

## 1085.59 Handhole.

- (a) Concrete. The concrete shall be Class SI according to Article 1020.
- (b) Composite Concrete. The composite concrete shall be according to Article 1085.18.

All hardware used for assembling the composite concrete double handhole shall be galvanized or stainless steel.

(c) Frame and Cover. The handhole frame and cover shall be fabricated from steel according to Section 505, or cast iron according to AASHTO M 105, Class 30 or better. The dimensions of the frame and cover shall be according to Standards 814001 and 813001, and the frame and the outer rim of the cover shall be a minimum of 19 mm (3/4 inches) thick. The thickness of the cover, at the center, shall be a minimum of 25 mm (1 inch) at the reinforcing ribs. The frame and cover shall have beveled edges to assist in centering the cover. Each cover of a double handhole shall be connected to the frame by a flush hinge.

The outside of the cover shall contain a recessed ring or handle for lifting and a cast in place legend "IDOT SIGNALS" or "IDOT LIGHTING" when used for traffic signals or highway lighting respectively. The frame and cover shall be designed to withstand AASHTO H 15 loading for a regular handhole and a double handhole, and to withstand AASHTO H 20 loading for a heavy-duty handhole. The frame and cover of a handhole shall have the minimum mass (weight) as follows:

Frame and Cover	<u>Minim</u>	<u>num</u>
	<u>Mass</u>	(Weight)
Handhole	64 kg	(140 lbs.)
Heavy-duty Handhole Double Handhole	118 kg 150 ka	(260 lbs.) (330 lbs.)

- (d) Lift Ring. The handhole lift ring shall have the same or better design life than the handhole cover and frame. The attachment of the lift ring to the lid by a loaded spring mechanism will not be acceptable.
- (e) French Drain. The French drain shall be constructed of crushed stone or gravel, Gradation CA 5 or CA 7, and according to Section 601.

## 1085.60 Gulfbox Junction.

- (a) Surrounding Material. The material surrounding the gulfbox shall be Class SI concrete and/or CA 6 Granular material according to Sections 1020 and 1004.
- (b) Cover. The gulfbox cover shall be either cast iron or composite concrete according to Article 1085.19 or Article 1085.18, respectively.
- (c) Cast Iron Box. The box shall be made of cast iron according to AASHTO M 105, Class 30 or better. The box shall be bottomless and 375 mm (14 3/4 inches) long, 300 mm (12 inches) wide and 200 mm (8 inches) deep.
- (d) Composite Concrete Box. The box shall be composite concrete according to Article 1085.18. The box shall be bottomless and 375 mm (14 3/4

inches) long, 375 mm (14 3/4 inches) wide and 320 mm (12 3/4 inches) deep.

## 1085.61 Emergency Vehicle Priority System.

(a) System Requirements. The system shall operate over an ambient temperature of -30 °C to 74 °C (-22 °F. to 165 °F.) and in 0 to 95 percent relative humidity.

All logic and timing circuitry shall be solid state. All printed circuit assemblies shall be according to NEMA Standards for Traffic Control Sytems, TS 1.

(b) Light Transmitter. The transmitter shall transmit a pulsed high intensity light energy in a forward direction. The on/off condition shall be controlled by an on/off switch and shall be indicated by a light located adjacent to the switch.

The transmitter shall operate on 10 to 15 VDC input voltage, but shall not be damaged by input voltage surges up to 25 VDC.

The transmitter shall not generate voltage transients on the battery input line which exceed the battery voltage by more than 4 V.

(c) Light Detector. The detector shall be capable of receiving high intensity light energy from one or both of two axially opposed directions, as indicated on the plans.

The internal circuitry of a detector unit shall be potted in a semi-flexible compound for moisture resistance.

The standard operating amperage shall be less than 6 amps.

Internal circuitry shall prevent electrical output due to steady state ambient light.

The confirmation beacon shall be a weatherproof floodlight fixture with a 150-watt long life floodlight.

(d) Light Detector Amplifier. The detector amplifier shall be a solid state design.

The detector amplifier shall have at least two channels and the capability of interfacing with another detector amplifier for channel expansion.

The detector amplifier shall have LED indicator lights to indicate power on, light energy being received, and channel called.

The detector amplifier, when actuated, shall continue to operate for at least 6 seconds after any interruption of light energy.

The detector amplifier shall sustain no permanent damage when subject to a transient produced by the discharge of a 10-microfarad capacitor charged to 600 volts and applied to the AC line.

# 1085.62 Traffic Signal Paint.

 (a) Composition. The primer shall be a corrosion inhibiting, lead and chromate free, alkyd coating according to Federal Specification TT-P-645B or TT-P-664D.

The finish coats shall produce a hard mar-resistant coating, free from paint cracks, sags, blisters or other defects and be according to the following:

Yellow Enamel Dull (matte) Black Aluminum (intermediate coat) Aluminum (final coat) Fed. Spec. TT-E-489H, color 13538 Fed. Spec. TT-E-527D, color 37038

Article 1008.20 Article 1008.19

When a finished surface is struck a light blow with a sharp tool, the paint shall not crack or chip. When a finished surface is scratched with a knife, the paint shall not powder.

## **SECTION 1086. GLARE SCREEN BLADES**

## 1086.01 Description.

- (a) General
  - (1) The blades shall have a minimum unit mass (weight) of 0.9 kg/m (0.6 lbs. per ft.). (The closed end shall be excluded from the total mass [weight] when determining the unit mass [weight].)
  - (2) Blades shall be green in color.
  - (3) Blades shall withstand a sharp bend test (180° bend without mandrel) at -18 °C (0 °F.) without failure.
- (b) Glare Screen Blades. Glare screen blades shall be manufactured of high density polyethylene according to plans details and as follows:
  - (1) Wall thickness shall be 2.5 mm (0.10 inch) minimum, except at corners where it shall be 1.5 mm (0.06 inch) minimum.
  - (2) Specific gravity of the polyethylene walls shall be between 0.94 and 0.965 as determined by ASTM D 792.
  - (3) Tensile strength shall be 20.7 MPa (3000 psi) minimum as determined by ASTM D 638M (D 638).
- (c) Modular Blade-Type Glare Screens. the blade-type screen modules shall be constructed of thermoplastic polyolefin (TPO) having the following physical properties:
  - (1) Wall thickness shall be 2.5 mm (0.10 inch) minimum.
  - (2) Specific gravity of the thermoplastic polyolefin walls shall be between 0.89 and 0.92 as determined by ASTM D 792.
  - (3) Tensile strength shall be 18 MPa (2,610 psi) minimum as determined by ASTM D 638M (D 638).

## Glare Screen Blades

- (d) Base Plates. Base plates shall be fabricated from 3 mm (1/8-inch) minimum steel plate according to AASHTO M 183M (M 183) and shall be galvanized according to AASHTO M 111 after fabrication.
- (e) Anchor Bolts. Anchor bolts shall consist of 10 mm (3/8-inch) expansion anchor studs with nut, flat washer and lock washer having a minimum pullout strength of 17.7 kN (4000 lbs.) and shall be zinc coated or stainless steel.
- (f) Self-Tapping Screws. Self-tapping screws shall be stainless steel 8 mm (5/16-inch) diameter x 16 mm (5/8-inch) Large Hex Head Type B and have an 8 x 22 mm (5/16 x 7/8-inch) outer diameter flat washer for each.

### SIGNS

## SECTION 1090, SIGN BASE

**1090.01 Sheet Aluminum.** The sign base material shall be flat sheet aluminum to which a chemical conversion coating has been applied. The material shall comply with ASTM B 209, Alloy 6061-T6 or 5052-H 38 and conversion coated according to either MIL-C-5541 or ASTM-B-449.

Type 1 sign panels shall be at least 2.03 mm (0.080 inch) thick. Type 2 sign panels shall be at least 3.17 mm (0.125 inch) thick. All panels shall be a flat continuous section of the length, width and shape specified in the plans for Standard Sign Design Criteria of the MUTCD with specified mounting holes and corner radii. Sign panels shall conform to dimensions specified, within  $\pm$  0.794 mm (1/32 inch) and shall not be out of square more than 1.588 mm (1/16 inch). Warps and buckles shall not exceed 1.588 mm (1/16 inch) for each foot in length or width when laid on a true flat surface. All fabrication shall be accomplished prior to the chemical conversion coating process.

Before reflective sheeting or paint is applied to the sign panel, the application surface shall be thoroughly cleaned, prepared or etched according to the sheeting or paint manufacturer's recommendations. The chemical conversion coating shall remain intact on the backside of the sign panel. There shall be no opportunity for the clean metal surface to oxidize or come in contact with grease, oils, or other contaminants prior to the application of reflective sheeting or paint.

**1090.02 Bolted Aluminum Extrusions.** Sign panels of this type shall be made of aluminum conforming to ASTM B 221, Alloy 6063-T 6.

Panel preparation shall comply with Article 1090.01, except etching may be omitted and holes for demountable sign legend units may be drilled after assembly and reflectorization.

Sign molding shall be an aluminum extrusion designed for the sign panel extrusion with which it is to be used and its color shall match the color of the sign background. The sign molding shall be riveted to the sign panel on 600 mm (2-foot) centers.

Aluminum dome head rivets shall be used to secure the sign molding, sign panel overlays, demountable legend unit, and supplemental panel to the sign face. The dome head rivets shall be 4.75 mm x 6.35 mm (3/16 inch x 1/4 inch) blind made from 5052 aluminum with an aluminum alloy mandrel. The dome head rivets shall have a grip range from 3.2 to 11.4 mm (0.126 to 0.250 inch) with a flange diameter of 2.9 mm (0.114 inch) and a rivet length of 11.4 mm (0.450 inch). The dome head rivets shall be color anodized to conform to the sheeting color of the unit being installed.

All bolts, nuts, and other hardware and material used in assembling aluminum extrusions into sign panels shall be stainless steel and shall be supplied by the manufacturer of the panels.

Aluminum post clips shall conform to ASTM B 108, Alloy SG 70A-T 6. A flat washer shall be used under each nut to prevent gouging of the clip.

Stainless steel bolts, nuts, and washers used for fastening extruded aluminum sign panels to supports, shall conform to ASTM A 276, Type 304. Nuts shall conform to A 240, Type 304. Stainless steel bolts, nuts, and washers shall be used with aluminum post clips when installing overhead-mounted sign panels.

**1090.03 Plywood.** Plywood furnished under this specification shall conform to the specified requirements of U.S. Product Standard PS 1-83, dated December 30, 1983, or hereafter referred to as PS 1-83. Each panel shall bear the mark of an approved testing agency or independent testing laboratory.

Plywood sign panels shall conform to the provisions of Section 3.4 of PS 1-83, except the inner plys may be made of plugged "C" quality veneers of Group 2 species. Both faces of the panels shall be "B" quality veneers of Group 1 species. The plywood shall have a nominal thickness of 19 mm (3/4 inch).

Both faces shall be high density overlay natural (buff), 60/60, in conformance with Section 3.6.8.1 of PS 1-83. Sign panel edges shall be smooth, straight, and free from tears and splinters, and the edges shall be sealed with two coats of aluminum paint conforming to Article 1008.19.

The plywood signs shall be square and free from warp and shall conform to Section 3.10 of PS 1-83.

If slip sheets are used, they must not deposit any wax, silicone, or other substance on the surface of the overlays.

There must be no caulk lubricant residue left on the surface of the overlays that will affect the adhesion of paint or reflective sheeting.

Plywood sign panels shall not be used with Type A reflective sheeting.

### **SECTION 1091. SIGN FACE**

1091.01 Reflective and Nonreflective Sheeting. The sheeting shall form a durable bond to smooth corrosion and weather-resistant surfaces and adhere securely at temperatures of -34 to 71 °C (-30 to 160 °F.). When subjected to any temperature within this range, the sheeting shall not crack, chip, or peel voluntarily, nor shall it be removable from the panel in one piece without the aid of a tool. The precoated adhesive, 48 hours after application, shall be elastic enough, at low temperatures, to resist shocking off when struck at -23 °C (-10 °F.), vandal resistant, and strong enough to resist appreciable peeling. The bond shall be sufficient to support a 0.8 kg mass (1 3/4-pound weight) attached to the free end of a specimen and allowed to hang free from an angle of 90° to the panel surface for 5 minutes without peeling more than 50 mm (2 inches) as outlined in the test for adhesive backing Federal Specifications L-S-300.

The sheeting color shall conform to the latest appropriate standard color tolerance chart issued by the U.S. Department of Transportation, Federal Highway Administration.

The sheeting shall have a protective liner and either a precoated pressure sensitive adhesive (Type 1), a tack free, heat activated adhesive (Type II), or a positionable pressure sensitive adhesive (Type III), each of which must be capable of being applied without additional adhesive coats on the reflective sheeting or application surface.

The Contractor shall provide a certification from an independent testing laboratory approved by the Department the material to be furnished meets all requirements of these specifications. The certification shall be forwarded to the Engineer of Materials and Physical Research, 126 East Ash Street, Springfield, Illinois 62706. The Department reserves the right to require three 300 mm (12-inch) by 600 mm (24-inch) samples representative of each color of material to be used. Any or

all material may be rejected if the tests performed on these samples indicate failure to meet these specifications.

The Department also reserves the right to inspect any completed sign face and reject any or all signs if the inspection indicates failure to meet these specifications.

## (a) Reflective.

Type A reflective sheeting shall consist of glass spherical lens elements adhered to a synthetic resin and encapsulated by a flexible, transparent, plastic having a smooth outer surface.

Types AA and AP reflective sheeting shall consist of a flexible colored, cube corner prismatic retroreflective material having a smooth outer surface.

Types BB, B, and C reflective sheeting shall consist of glass spherical lens elements embedded within a flexible, transparent, plastic film having a smooth, flat outer surface.



The reflective sheeting color conformance may also be shown through instrumental color testing, the diffuse day color of the reflective material shall conform to Table 1 (Types AA, AP, BB, B, or C sheeting) or Table II (Type A sheeting) of Article 726.03 on Federal Highway Projects (FP-85).

The reflective sheeting shall have the minimum brightness values shown in Table 1091-1 for the type and color of material specified. The reflective intensity shall be determined by the procedures described in ASTM E 810.

The brightness of the reflective sheeting totally wet shall not be less than 90 percent of the reflective values shown in Table 1091-1 when tested in conformance with the procedure outlined in Section 7.10.1 of AASHTO M 268.

The thickness of the reflective sheeting without protective liner shall not be more than 0.4 mm (0.015 inch) for Type A, BB, B, and C and not more than 0.6 mm (0.025 inch) for Type AA and AP.

When tested according to Section 4.3.15 of Federal Specification L-S-300, the reflective sheeting with the liner removed shall have a tensile strength between 0.9 N and 4.4 N per mm (5 pounds and 25 pounds per inch) of width.

Following removal of the protective liner, the reflective sheeting shall not shrink more than 0.8 mm (1/32 inch) in 10 minutes nor more than 3.2 mm (1/8 inch) in 24 hours in any dimension per 225 mm (9-inch) square at 24  $\pm$  4 °C (75  $\pm$  5 °F.) and 50  $\pm$  5 percent relative humidity.

Type A, AA and AP sheeting with the liner removed and conditioned for 24 hours at  $22\pm4$  °C ( $72\pm5$  °F.) and  $50\pm5$  percent relative humidity shall be sufficiently flexible to show no cracking when slowly bent, in one second's time, around a 3.2 mm (1/8-inch) mandrel with adhesive contacting the mandrel (the adhesive may be coated with talcum powder to prevent sticking).

Types BB, B, and C sheeting, when applied according to manufacturer's recommendations to cleaned and etched 0.5 mm (0.20-inch) by 50 mm

(2-inch) by 200 mm (8-inch) aluminum (Alloy 6061-T6) sections conditioned for 48 hours, and tested at 22  $\pm$  4 °C (72  $\pm$  5 °F.) and 50  $\pm$  5 percent relative humidity, shall be sufficiently flexible to show no cracking when bent around a 19 mm (3/4 inch) mandrel.

The reflective material shall be processed and applied directly to properly prepared sign bases according to the sheeting manufacturer's recommended procedures. The reflective material shall be weather resistant and, following cleaning, shall show no appreciable discoloration, cracking, crazing, blistering, or dimensional change and shall meet the requirements shown in Table 1091-1 when exposed to the corresponding hours of accelerated weathering shown. The test specimens shall be cleaned by immersing in 5 percent hydrochloric acid 45 seconds, rinsing with water and blotting dry with a soft clean cloth. The Recommended Practice for Operating Light-and-Water Exposure Apparatus (Fluorescent UV-Condensation Type) for Exposure of Nonmetallic Materials, ASTM G53 shall govern the weathering testing. The cycle used shall consist of 8 hours of light at 60 °C followed by 4 hours of condensation at 40 °C.

# Accelerated Weathering Minimum

<u>Material</u>	Exposure Time	<u>Brightness</u>
Types AA,AP&A Type BB	*1,000 hours *1,000 hours	80% Table 1091-1 65% Table 1091-1
Type B	500 hours	50% Table 1091-1
Type C	300 hours	50% Table 1091-1

\*Orange Types A and BB and fluorescent orange Types AA and AP shall have an exposure time of 300 hours.

Types A, AA, and AP sheeting shall permit cutting and color processing according to the sheeting manufacturer's recommendations at temperatures of 15 to 38 °C (60 to 100 °F.) and relative humidity of 20 to 80 percent. The sheeting shall be heat resistant and permit forced curing without staining of applied or unapplied sheeting at temperatures recommended by the manufacturer. The sheeting shall be solvent resistant and capable of being cleaned with VM&P naptha, mineral spirits, and turpentine.

Types BB, B, or C sheeting shall be such that cutting and color processing at temperatures 10 to 43 °C (50 to 110 °F.) and relative humidities of 20 to 80 percent will be possible. The sheeting shall be heat resistant and permit force curing without staining of applied or unapplied sheeting at temperatures up to 66 °C (150 °F.) and up to 93 °C (200 °F.) on applied sheeting. The sheeting surface shall be solvent resistant and may be cleaned with VM&P naptha, mineral spirits, turpentine, methanol, or xylol.

The sheeting surface shall exhibit an 85° gloss-meter rating of not less than 50 for Types A, AA, AP and BB and 40 for Type B when tested according to ASTM D 523.

Sign faces for all Interstate Route shields (M1-1), auxiliary plates having a blue background with white legend (M2, 3, 4, 5, and 6), red Type 1 object markers and all STOP (R1-1), YIELD (R1-2), ALL-WAY (R1-4), do not enter

symbol (R5-1), WRONG WAY (R5-9), chevron alignment (W1-8), STOP AHEAD (W3-1), (W3-1a), YIELD AHEAD (W3-2a), RAILROAD ADVANCE WARNING (W10-1), and NO PASSING ZONE (W14-3) shall be fabricated with faces of Type A reflective sheeting. Mast arm mounted street name signs shall be fabricated with faces of Type A or Type BB reflective sheeting. All route shields and auxiliary panels mounted on signs with Type A reflective sheeting faces shall also have Type A reflective sheeting.



On fully access-controlled sections of highway (freeways or expressways), all reflectorized signs and supplemental panels shall be fabricated using faces of Type A reflective sheeting. This shall include mainline, ramp, crossroad interchange approach directional signing, route markers, and all signs within the interchange.

Sign faces, legend, overlay, or supplemental panels shall not be fabricated with Type C reflective sheeting.

All warning signs (W series), all SPEED LIMIT (R2-1), SPEED ZONE AHEAD (R2-5C), advisory speed (R2-1101), and all green destination and information (D and I series) signs not otherwise specified shall be fabricated with faces of Type A or Type BB reflective sheeting.

Sign faces comprising two or more pieces or panels of reflective sheeting must be carefully matched for color at the time of sign fabrication to provide uniform appearance and brilliance, both day and night. Successive width sections of either sheeting or panels must be consecutively reversed to ensure corresponding edges of reflective sheeting lie adjacent on the finished sign. Nonconformance may result in rejection of the sign face.

At splices, Type I and Type III adhesive coated sheeting shall be overlapped not less than 4.8 mm (3/16 inch). Type II adhesive coated sheeting may be spliced using an overlap splice of not less than 4.8 mm (3/16 inch) or butted with a gap splice not exceeding 0.8 mm (1/32 inch). Only butt splices will be permitted on signs screen-processed with a transparent color using Type BB, B, or C sheeting materials. Only overlap splices will be permitted on signs screen-processed with translucent color using Type A, AA and AP sheeting material.

Types A, AA, AP and BB sheeting shall have a distinctive overall permanent identifying symbol (watermark) unique to the individual manufacturer incorporated into the sheeting and shall be visible to the naked eye within 0.9 m (3 ft.) without the use of special devices. The symbol shall repeat at intervals no greater than 203 mm (8 inches) both vertically and horizontally. A distinctive overall pattern in the sheeting unique to the individual manufacturer may be used in lieu of a symbol. Neither the symbol or the overall pattern shall interfere with the reflectivity of the sheeting. If material orientation is required for optimum retroreflectivity, permanent marks indicating direction of orientation shall be incorporated into the face of the sheeting and shall be readily visible to the sign fabricator.

Where recommended by the manufacturer, reflective sheeting shall be coated with a full glossy coat of clear finish, approved by the sheeting manufacturer.

Table 1091-1

Type AA

# (0 to 90 degree Rotation Angle)

	Observation Angle 0.2 Entrance Angle			Observation Angle 0.5 Entrance Angle	
Color	-4	+30	-4	+30	
White	800.0	400.0	200.0	100.0	
Yellow	660.0	340.0	160.0	85.0	
Orange*	-200.0	120.0	80.0	50.0	
Red	215.0	100.0	45.0	26.0	
Green	75.0	30.0	18.0	10.0	
Blue	43.0	20.0	9.8	5.0	
Brown	N/A	N/A	N/A	N/A	
	<u>(4</u>	5 degree Rota	tion Angle)		
Yellow Orange*	550.0 165.0	130.0 45.0	145.0 70.0	70.0 40.0	

<sup>\*</sup>Fluorescent Orange

# Type AP

	•	Observation Entrance A	•
-4	+30	-4	+30
250.0	80.0	135.0	55.0
170.0	54.0	100.0	37.0
105.0	30.0	60.0	22.0
35.0	9.0	17.0	6.5
35.0	9.0	17.0	6.5
20.0	5.0	10.0	3.5
7.0	2.0	4.0	1.4
	Entrance A -4 250.0 170.0 105.0 35.0 35.0 20.0	250.0 80.0 170.0 54.0 105.0 30.0 35.0 9.0 35.0 9.0 20.0 5.0	Entrance Angle

<sup>\*</sup>Fluorescent Orange

		Olgir i acc		7.11.1001.01	
Type A					
Color	Observation A Entrance Angl -4	ngle 0.2 e +30	Observation Entrance A	on Angle 0.5 Angle +30	
Silver/White Yellow Orange Red Green Blue Brown	250.0 170.0 100.0 45.0 45.0 20.0 12.0	150.0 100.0 60.0 25.0 25.0 12.0 8.5	95.0 65.0 30.0 15.0 15.0 8.0 5.0	75.0 50.0 25.0 10.0 10.0 5.0 3.5	
		Type BB			
Color	Observation A Entrance Angl -4	ngle 0.2 e +30	Observation Entrance 7	on Angle 0.5 Angle +30	
Silver/White Yellow Orange Red Green Blue Brown	140.0 100.0 60.0 30.0 30.0 10.0 5.0	60.0 36.0 22.0 12.0 10.0 4.0 2.0	50.0 33.0 20.0 10.0 9.0 3.0 2.0	28.0 20.0 12.0 6.0 6.0 2.0 1.0	
		Type B			
Color	Observation A Entrance Angl -4	ngle 0.2 e +30	Observation Entrance 7	on Angle 0.5 Angle +30	
Silver/White Yellow Orange Red Green Blue Brown	90.0 60.0 30.0 16.5 11.0 5.0 3.0	40.0 30.0 12.0 8.0 5.0 2.0	41.0 25.0 15.0 8.0 5.0 2.5 1.5	21.0 13.0 10.0 5.0 2.5 0.8 0.6	
		Type C			
Color	Observation A Entrance Angl -4	-	Observation Entrance / -4	on Angle 0.5 Angle +30	
Silver/White Yellow Orange Red Green Blue Brown	50.0 25.0 25.0 10.0 5.0 4.0	12.0 7.0 5.8 3.0 2.0 1.0 0.1	15.0 10.0 12.5 5.0 3.0 2.0	6.0 3.0 3.0 1.0 1.0 0.5	

## (b) Nonreflective Sheeting

The nonreflective sheeting shall consist of a flexible, pigmented plastic film completely precoated with an adhesive, protected by a liner and shall meet the following requirements:

The thickness of the sheeting without a protective liner shall be a minimum of 0.07 mm (0.003 inch) and a maximum of 0.13 mm (0.005 inch).

The sheeting shall have an average initial 60° glossmeter value of at least 40 when tested according to ASTM D 523, measuring at least three portions of the film to obtain uniformity.

Test panels shall be prepared using 165 mm by 165 mm (6 1/2 inch by 6 1/2 inch) pieces of sheeting premasked as recommended by the manufacturer to an aluminum panel according to Article 1090.01, trimmed evenly at the edges of the panel, and aged for 48 hours at 21 to 32  $^{\circ}$ C (70 to 90  $^{\circ}$ F.).

The sheeting shall not shrink more than 0.4 mm (1/64 inch) from any panel edge when the test panel is subjected to a temperature of 66 °C (150 °F.) for 48 hours and shall be sufficiently heat resistant to retain adhesion after one week at 66 °C (150 °F.).

Unprocessed sheeting that has been exposed to the elements shall show no appreciable discoloration, cracking, crazing, blistering, delamination, or loss of adhesion, according to the following type of adhesion and length of exposure:

Type I and III Adhesive Sheeting - 7 years

Type II Adhesive Sheeting - 5 years

A slight amount of chalking is permitted but the sheeting shall not support fungus growth.

The test panels, when immersed to a depth of 50 to 75 mm (2 to 3 inches) in the following solutions at 21 to 32 °C (70 to 90 °F.) for the specified times and examined 1 hour after removal, shall show no appreciable decrease in adhesion, color, or general appearance.

	Solution	Hours Immersion
   	Reference Fuel (MIL-F-8799A) (15 parts xylol and 85 parts mineral spirits by weight)	1
I	Distilled Water	24
I	SAE No. 20 Motor Oil	24
	Antifreeze (1/2 ethylene glycol, 1/2 distilled water)	24

**1091.02 Enamel Paint.** Enamel paint shall meet the recommendations of the manufacturer of the sign background material, except the color shall be as specified

on the plans and shall conform to the color tolerance chart issued by the U.S. Department of Transportation, Federal Highway Administration.

#### SECTION 1092. SIGN LEGEND AND SUPPLEMENTAL PANELS

**1092.01 General.** Letters and numerals used shall conform to the standard alphabets for highway signs (available from the Federal Highway Administration) of the series indicated in the design details for the sign.

When uppercase and lowercase letters and related numerals are called for, they will be Series E of the standard alphabets modified by widening the stroke width to approximately one-fifth the letter or numeral height. A suitable design for the lowercase alphabet is also available from the Federal Highway Administration.

When capital letters and related numerals are called for, they will be Series D of the standard alphabet modified by widening the stroke width to approximately one-fifth of the letter or numeral height. Lowercase letters are not used with capital letters.

Each demountable legend unit, supplemental panel, and border frame shall be supplied with mounting holes and shall be secured to the sign face with aluminum dome head rivets with aluminum mandrels and may not be held in place, even temporarily, using any type of adhesive that would damage the sign face, legend unit or border when removed at a later date. All rivets shall be color matched to the legend or supplemental panel being installed.

When recommended by the sheeting manufacturer, the completed demountable legend units, supplemental panels, and borders shall be coated with finishing clear as approved by the sheeting manufacturer. Finishing clear shall be appled to the sheeting surface in a manner to assure a fully glossy coat and a complete edge seal of the sheeting.

The finished letters, numerals, symbols, panels, and borders shall show careful workmanship and be clean cut, sharp, and have essentially a plane surface.

(a) Direct Applied Legend. All direct applied sign legend and borders shall be affixed to clean, dust-free sign panels in a manner specified by the legend manufacturer. The legend and border shall be cut neatly at any intersecting panel edge.

Direct applied reflective sheeting, Type A, Type B or Type BB and nonreflective sheeting used for legend and border shall be according to Article 1091.01

The sheeting may be manufactured with a thin aluminum layer between the sheeting and the precoated adhesive.

(b) Flat Frames. The reflective sheeting Type A and nonreflective sheeting used on flat frames for legend and border shall be according to Article 1091.01

Flat frames shall be 0.8 mm (0.032 inch) aluminum according to ASTM B 209, Alloy 3003-H 14. The frames shall be properly degreased and etched and treated with a light, tight, amorphous chromate type coating before any sheeting is applied.

(c) Supplemental Panels. All supplemental panels shall consist of 2 mm (0.080

inch) sheet aluminum according to Article 1090.01 with reflective sheeting applied according to Article 1090.01.

(d) Transparent and Opaque Silk Screen Inks. The silk screen inks shall be according to the recommendations of the manufacturer of the sign background material and be applied according to the ink manufacturer's recommendation.

#### SECTION 1093, SIGN SUPPORTS

## 1093.01 Supports.

- (a) Structural Steel. Steel shall have a silicone content suitable for galvanizing.
  - Breakaway. All structural steel shall be according to AASHTO M 183M (M 183).

After fabrication, the post, fuse plate, base plate, and upper 150 mm (6 inches) of the stub post shall be galvanized according to AASHTO M 111. Bolts and nuts on the fuse plates may be plated according to ASTM B 633M (B 633) SC3 and then painted with an approved zinc rich paint.

All high strength bolts, nuts, and washers shall be according to Article 1006.08.

(2) Tubular. Hollow structural steel tubing shall conform to ASTM A 500 Grade B or ASTM A 501.

After fabrication, the post, base plate, and upper 150 mm (6 inches) of the stud post shall be galvanized according to AASHTO M 111.

All high strength bolts, nuts, and washers shall be according to Article 1006.08.

(3) Telescoping. The post shall be a square tube formed of 12 gauge steel according to the standard specification for cold rolled carbon steel sheets commercial quality ASTM A 366. The post shall be formed to size and, if necessary, shall be welded in such a manner that weld or flash shall not interfere with telescoping. Holes  $11 \pm 0.4$  mm  $(7/16 \pm 1/64 \text{ inch})$  will be spaced on 25 mm (1 inch) centers on at least two opposite sides. The holes shall align to accept a 10 mm (3/8 inch) bolt through the post at any location. The post shall have a smooth galvanized finish applied either before or after forming.

The following tolerances will be permitted:

The nominal outside dimension will not vary more than  $\pm$  0.2 mm ( $\pm$  0.008 inch)  $\pm$  2.5 mm ( $\pm$  0.10 inch) for the 57 mm (2 1/4 inch) size from the dimension stipulated. The wall thickness will not vary more than + 0.28 mm to -0.20 mm (+ 0.011 inch to -0.008 inch) from the standard 12 gauge plate thickness. The maximum allowable twist in a 1 m (3 ft.) length and the permissible variation in squareness shall be as shown in the following table:

Art.	1093.0	1
, v. c.	1000.0	

Post Size	<u>Squareness</u>	<u>Twist</u>	
44 mm x 44 mm 51 mm x 51 mm 57 mm x 57 mm	$\pm$ 0.25 mm $\pm$ 0.30 mm $\pm$ 0.35 mm	1.7 mm 1.7 mm 1.7 mm	
Post Size	Squareness	Twist	
1 3/4 inches x 1 3/4 inches 2 inches x 2 inches 2 1/4 inches x 2 1/4 inches	$\pm 0.010$ inch $\pm 0.012$ inch $\pm 0.014$ inch	0.062 inch 0.062 inch 0.062 inch	

The posts shall be straight and have a smooth uniform finish. It shall be possible to telescope all consecutive sizes of posts freely and for at least 3.0 m (10 ft.) of their length without the necessity of matching any particular face to any other face. All holes and ends shall be free from burrs and ends shall be cut square.

The posts shall be hot-dipped galvanized according to AASHTO M 111, or given triple coated protection by in-line application of hot-dip galvanized zinc per AASHTO M 111 followed by a chromate conversion coating and a cross-linked polyurethane acrylic exterior coating. The inside surfaces shall be given corrosion protection by in-line application of a full zinc base organic coating after fabrication, tested in accordance with ASTM B117. If a weld process is performed after galvanizing, the weld shall be zinc-coated after the scarfing operation.

(b) Wood. Southern Pine No. 2 or better - Structural Joints and Planks, according to Paragraph 343 of the Southern Pine Inspection Bureau Grading Rules or Douglas Fir No. 2 - Structural Joists and Planks, according to Paragraph 123C of the West Coast Lumber Inspection Bureau Standard Grading Rules shall be used.

The posts shall be nominal 100 mm by 150 mm (4 inches by 6 inches) and rectangular in shape with the lengths of the posts as specified in the plans. The posts shall be surfaced on all four sides (S4S).

Wood signposts shall be pressure treated according to Article 1007.12 except creosote oil shall not be used.

**1093.02** Base for Telescoping Sign Support. The base shall be cast from iron conforming to ASTM A 126 Class A. The finished casting shall be free from burrs, cracks, voids, or other defects.

After being thoroughly cleaned of all grease, dirt, oil, and loose scale, the casting shall be primed with 2 coats of paint according to the requirements of Article 1008.19. The exterior shall be finished with 2 coats of aluminum paint according to the applicable requirements of Articles 506.01 to 506.03, inclusive, and 506.05.

The nominal inside dimension of the square hole shall not vary more than 1.6 mm (1/16 inch) from the dimension shown in the plans.

1093.03 Concrete Foundation for Wood Posts. This type of sign support foundation shall be fabricated with Class SI concrete, according to the applicable

requirements of Section 734.

The reinforcement bars to be incorporated in this foundation shall be No. 10 (No. 3) and shall be furnished according to the applicable portions of Section 508.

# **SECTION 1094. OVERHEAD SIGN STRUCTURES**

- **1094.01 General.** Materials used in the fabrication of trusses, cantilevers, and bridge-mounted sign structures, including their supports and walkways, shall be according to the specifications set forth in the plans and the following: High Strength Steel Bolts, Nuts and Hardened Washers, Fabric Pads, Stainless Steel Bolts and Screws.
- **1094.02 Stainless Steel Nuts.** All stainless steel nuts shall be according to Article 1006.29(d). The nuts shall be "locknuts" with semifinished hexagonal heads equivalent to the finished hex series of the American National Standard.
- **1094.03 Anchor Bolts, Nuts, and Rods.** Anchor bolts shall conform to the requirements of Article 1006.09 and bolts, nuts and washers shall be galvanized.

Anchor rods shall be according to AASHTO M 314, Grade 250 or 380 (Grade 36 or 55) with a minimum CVN energy of 20 J (15 ft. lbs.) +4  $^{\circ}$ C (40  $^{\circ}$ F.). The upper 300 mm (12 inches) of the threaded end of the anchor rods shall be galvanized according to AASHTO M 232.

- **1094.04 Conduit.** All conduit furnished shall be 75 mm (3 inch) nominal size and shall comply with ANSI C 80.1 or 80.5. The interior and exterior surfaces of steel conduit shall be galvanized.
- **1094.05 Mounting Hardware.** Carbon steel bolts, nuts, and washers shall be according to ASTM A 307, Grade A and either AASHTO M 232, Class D, or ASTM B 633M (B 633) SC3.

All bolts, nuts, and flat washers shall be coated in conformance with one of the following: AASHTO M 232, Class D; ASTM A 164, Grade GS; or ASTM A 165, Grade NS.

- **1094.06 Structural Aluminum.** The aluminum alloys to be welded under these specifications may be any of the following ASTM designations:
  - (a) Aluminum Fabrication. Aluminum shall be assembled, welded, and inspected according to ANSI/AWS D1.2, "Structural Welding Code-Aluminum", except as herein modified.
  - (b) Load-carrying Elements. All primary load-carrying elements shall be evaluated as Class I structures by the D 1.2 code.

Wrought nonheat-treatable alloys: Alloy 3003 and Alloy 3004

Wrought heat-treatable alloys: Alloy 6061 and Alloy 6063

Cast heat-treatable alloys: ASTM B 26 or B 108, Alloy A 356-T61, A444-T4, or AASHTO M193.

Material used for permanent backing shall be at least equivalent in weldability to the base metal being welded.

(c) Welding Processes. These specifications include provisions for welding by the gas metal-arc process and the gas tungsten-arc process. Other processes may not be used, except as permitted by the Engineer.

Tungsten electrodes for the gas tungsten-arc process shall conform to the requirements of the latest edition of Specification for Tungsten-Arc Welding Electrodes, AWS A 5.12.

Filler metals to be used with particular base metals shall be as shown in Table 1. Other filler metals may be used as approved by the Engineer or as specified in the plans.

Table 1

Base Metal	Filler Metal
3003 to 3003 3004 to 3004 3003 to 6061 6061 to 6061 6063 to 6063 A356-T61 or	ER1100 ER4043 ER5183 or 5356 ER5356* ER5356*
A444-T4 to 3003	ER4043 or 4145
A356-T61 or A444-T4 to 6061 A356-T61 or	ER4043 or 4145
A444-T4 to 6063 A356-T61 to A356-T61 A444-T4 to A444-74	ER4043 ER4043 ER4043

<sup>\*</sup> ER5356 and ER5556 may be used interchangeably for these base metals.

Filler metals shall be kept covered and stored in a dry place at relatively uniform temperatures. Original rod or wire containers shall not be opened until time to be used. Rod and wire shall be free of moisture, lubricant, or other contaminants. Spools of wire temporarily left unused on the welding machine shall be kept covered to avoid contamination by dirt and grease collecting on the wire. If a spool of wire is to be unused for more than a short length of time, it shall be returned to the carton and the carton tightly resealed.

(d) Shielding Gases. Shielding gas for gas metal-arc welding shall be argon, helium, or a mixture of the two (approximately 75 percent helium and 25 percent argon).

Shielding gas for gas tungsten-arc welding done with alternating current shall be argon.

Shielding gas for tungsten-arc welding done with direct current, straight polarity, shall be helium.

Hose used for shielding gases shall be made of synthetic rubber or plastic. Natural rubber hose shall not be used. Hose that has been previously used for acetylene or other gases shall not be used.

(e) Preparation of Materials. Joint details shall be according to design requirements and detail drawings. The locations of joints shall not be changed without the approval of the Engineer.

Edge preparation shall be by sawing, machining, clipping, or shearing. Gas tungsten-arc or gas metal-arc cutting may also be used. Cut surfaces shall meet the American Standards Association's surface roughness rating value of 1,000. Oxygen cutting shall not be used.

Surfaces and edges to be welded shall be free from fins, tears, and other defects that would adversely affect the quality of the weld.

Dirt, grease, forming or machining lubricants, or any organic materials shall be removed from the areas to be welded by cleaning with a suitable solvent or by vapor degreasing.

The oxide shall be removed from all edges and surfaces to be welded just prior to welding by wire brushing or by other mechanical methods, such as rubbing with steel wool or abrasive cloth, scraping, filing, rotary planing, or sanding. If wire brushing is used, the brushes shall be made of stainless steel. Hand or power driven wire brushes and other mechanical devices that have been used on other materials shall not be used on aluminum.

Where mechanical methods of oxide removal are found to be inadequate, a standard chemical method shall be used. Welding shall be done within 24 hours after chemical treatment.

When gas tungsten-arc welding with direct current, straight polarity, is being used, all edges and surfaces to be welded shall have the oxide removed by a standard chemical method.

Welding shall not be done on anodically treated aluminum unless the condition is removed from the joint area to be welded.

(f) Welding Procedure. All butt welds requiring 100 percent penetration, except those produced with the aid of backing, shall have the root of the initial weld chipped or machined out to sound metal before welding is started from the second side. Butt welds made with the use of backing shall have the weld metal thoroughly fused with the backing. Where accessible, backing for welds that are subject to computed stress or which are exposed to view on the completed structure and which are not otherwise parts of the structure shall be removed and the joints ground or machined smooth. In tubular members, butt welds subjected to computed stresses shall be made with the aid of permanent backing rings or strips.

The procedure used for production welding of any particular joint shall be the same as used in the procedure qualification for the joint.

All welding operations, either shop or field, shall be protected from air currents or drafts so as to prevent any loss of gas shielding during welding. Adequate gas shielding shall be provided to protect the molten metal during solidification.

The work shall be positioned for flat postion welding whenever practicable.

In both shop and field, all weld joints shall be dry at time of welding.

The size of the electrode, voltage and amperage, welding speed, gas or gas mixture, and gas flow rate shall be suitable for the thickness of the material, design of joint, welding position, and other circumstances influencing the work, and shall be shown on the approved Weld Procedure Specification (WPS).

Gas metal-arc welding shall be done with direct current, reverse polarity.

Gas tungsten-arc welding shall be done with alternating current or straight polarity direct current.

The Contractor shall submit to the Engineer, at his request, two weld samples for destructive testing and macroetching. These samples shall be welded according to the procedures that will be used in production welding. The Contractor shall submit to the Engineer for approval, the procedure to be used for the test samples and production welding. Should test of these samples indicate unsatisfactory welding, additional samples shall be furnished without cost to the Department. Poor workmanship as noted by visual inspection shall be sufficient cause for rejection.

Where preheat is needed, the temperature of preheat shall not exceed 177 °C (350 °F.) for nonheat-treated alloys. The temperature shall be measured by temperature indicating crayons or by contact or accurate ( $\pm$  2 °C) non-contact pyrometric equipment. Heat-treated alloys shall not be held at or near the maximum preheat temperature for more than 35 minutes.

(g) Welding Quality. Regardless of the method of inspection, the acceptance or rejection of welds shall comply with the D 1.2 Code and the following conditions:

Welds having defects exceeding the levels of acceptance specified shall be considered as rejected unless corrected according to Article 1094.06(i).

Undercut shall not be more than 0.25 mm (0.01 inch) deep when its direction is transverse to the primary stress in the part that is undercut. Undercut shall not be more than 0.80 mm (1/32 inch) deep when its direction is parallel to the primary stress in the part that is undercut. When undercut is present, the affected area shall be ground to a smooth transition.

(h) Nondestructive Examination/Nondestructive Testing (NDE/NDT). To determine compliance with these specifications, all welds shall be visually inspected and, in addition, complete joint penetration welds subjected to computed stress shall be inspected by radiographic testing (RT) for butt welds and ultrasonic testing (UT) for T and corner joints. RT shall utilize aluminum edge blocks and location marks similar to those specified for steel in Article 505.04 in addition to the D1.2 requirements.

The dye penetrant testing (DPT) shall be performed according to ASTM E 165, Standard Methods for Liquid Penetrant Inspection, Method B, Procedure B-2 or B-3. PT shall be used on partial joint penetration and fillet welds as follows:

100% of the top and bottom cantilever truss chords to connection and gusset plates near column;

#### Overhead Sign Structures

25% of top connection plate to collar;

100% of simple span plice flanges to main chords, and

random 10% of main chords to diagonals, horizontals, and verticals as directed by the Engineer.

Dye penetrant inspection may be omitted, provided the inspector examines each layer of weld metal with a magnifier of 3X minimum before the next successive layer is deposited.

Required NDE/NDT shall be the responsibility of the Contractor and its cost shall be included in the fabrication.

(i) Corrections. In lieu of rejection of an entire member containing welding that is unacceptable, the corrective measures may be permitted by the Engineer, if the extent of repairs will not adversely effect the structure's serviceability.

Defective welds shall be corrected by removing and replacing the entire weld or as permitted by D1.2 Code. Copper or tungsten inclusions shall be completely removed.

Before rewelding, the joint shall be inspected to assure all of the defective weld has been removed. If dye penetrant has been used to inspect the weld, all traces of penetrant solutions shall be removed with solvent, water, heat, or other suitable means before rewelding.

Repaired areas shall be 100% inspected by RT, UT or PT as applicable.

(j) Qualification of Procedures, Welders, and Welding Operators. Joint welding procedures that are to be employed under these specifications shall be qualified by tests prescribed in the D1.2 Code. The qualifications shall be at the expense of the Contractor. The Engineer may accept properly documented evidence of previous qualification of the joint welding procedures to be employed.

All welders and welding operators shall be qualified by tests specified by the D1.2 Code. The Engineer may accept properly documented evidence of previous qualification of the welders and welding operators to be employed.

**1094.07 Structural Steel.** All structural steel pipe shall be ASTM A-53 Grade B with a minimum yield of 240 MPa (35 ksi) or A 500 Grade B or C with a minimum yield of 317 MPa (46 ksi). All structural steel plates and shapes shall be according to AASHTO M 270M, Grades 250, 345, or 345W (M 270, Grades, 36, 50, or 50 W), M 183M (M 183), M 223M, Grade 345 (M 223 Grade 50) or M 222M (M 222). Stainless steel for shims and handhole covers shall be ASTM A 240, Type 302 or 304, or another alloy suitable for exterior exposure and acceptable to the Engineer. Steel to be hot dip galvanized shall have a silicon content either less than 0.04% or between 0.15% and 0.25%.

#### **SECTION 1095. PAVEMENT MARKINGS**

**1095.01 Thermoplastic Pavement Markings.** The material shall be a mixture of resins and other materials providing an essentially nonvolatile thermoplastic compound especially developed for traffic markings.

- (a) Binder. The binder shall consist of a mixture of synthetic resins, at least one of which is solid at room temperature. The total binder content of the thermoplastic compound shall be well distributed throughout the compound. The binder shall be free from all foreign objects or ingredients that would cause bleeding, staining, or discoloration. The binder shall be 18 percent minimum by weight of the thermoplastic compound. The binder shall be characterized by an IR Spectra. Future shipments of binder will be checked by an IR Spectra to verify that the binder has not been changed.
- (b) Pigment. The pigment used for the white thermoplastic compound shall be a high grade pure (minimum 93 percent) titanium dioxide (Ti0²). The white pigment content shall not be less than 10 percent by weight and shall be uniformly distributed throughout the thermoplastic compound.

The pigments used for the yellow thermoplastic compound shall be heat resistant and color fast yellows, golds, and oranges, which shall produce a compound meeting the requirements of the current Federal Highway Color Tolerance Chart, PR Color No. 1. The medium chrome yellow pigment content shall not be less than 4 percent by weight and shall be uniformly distributed throughout the thermoplastic compound.

(c) Filler. The filler to be incorporated with the resins as a binder shall be a white calcium carbonate, silica, or an approved substitute.

Any filler which is insoluble in 6N hydrochloric acid must pass a 150  $\mu m$  (No. 100) sieve.

(d) Glass Beads. The glass beads used for reflectorizing pavement marking lines are as follows:

Type A - uncoated
Type B - moisture resistant, silicone coated

- (1) Type A shall be used as intermix beads with thermoplastic pavement marking materials. They shall be uniformly mixed throughout the material at the rate of not less than 30 percent by weight of thermoplastic compound, retained on 150 μm (No. 100 sieve).
- (2) Type B shall be used as drop-on beads with thermoplastic pavement marking materials and shall be applied uniformly at a minimum rate of 39 kg (8 pounds) per 100 m<sup>2</sup> (100 sq. ft.).
  - a. Packing. The glass beads shall be delivered in approved moisture proof bags consisting of at least five-ply paper construction unless otherwise specified. Each bag shall contain 22.5 kg (50 pounds) net, and shall be legibly marked with the manufacturer, specification and type, lot number, and the month and year the glass beads were packaged.
  - b. Properties. The glass beads furnished under this specification shall consist essentially of transparent, water-white glass particles of a spherical shape. They shall be manufactured from a glass of a composition designed to be highly resistant to traffic wear and to the effects of weathering. The glass beads shall conform to the following requirements:
    - Sieve Analysis. The glass beads shall meet the following sieve requirements:

#### **Pavement Markings**

Sieve	U.S. Standard	Total Percent By
<u>Sizes</u>	Sieve No.	Mass (Weight) Passing
850 μm	20	100
600 μm	30	75-100
300 μm	50	15-40
150 μm	100	0-5
75 μm	200	0-1

- Imperfections. The surface of the glass beads shall be free
  of pits and scratches. The glass beads shall be spherical in
  shape and shall contain less than 20 percent irregular
  shapes, by weight, when tested by the standard method
  using a bibratile inclined glass plate as adopted by the
  Department.
- 3. Index of Refraction. The index of refraction of the glass beads shall be 1.50 or greater when tested by the immersion method at 25 °C (77 °).
- Silica Content. The glass beads shall contain at least 65 percent silica (Si0<sub>2</sub>).
- 5. Chemical Stability. Glass beads which show tendency toward decomposition, including surface etching, when exposed to paint or thermoplastic constituents will be rejected. The glass beads shall be tested by Federal Specification TT-B-1325A, Section 4.3.11 (water resistance soxhlet extraction method) with the following exceptions: Under "Procedure" the size of sample to be tested shall be 25 grams. Under testing Paragraph (1), the reflux-time shall be 5 hours and upon examination after testing the glass beads shall show no dulling effect. Under Paragraph (2), if more than 4.5 mls. of 0.1N hydrochloric acid is used to reach the end point, it shall constitute failure of the test.
- 6. Reflectivity. Beaded glass panels having a minimum reflective area of 116,000 mm<sup>2</sup> (180 sq. in.) shall be prepared in the following manner:

A standard white pavement marking paint, approved by the Department, shall be applied to the panels by means of a doctor blade to a wet film thickness of 0.38 mm (0.015 in.). The glass beads shall be applied immediately in a uniform layer in the proportion of 0.7 kg (6 lbs.) of glass beads to one liter (gallon) of paint. The panels shall be allowed to dry for approximately 24 hours before testing.

The coefficient of retroreflection (apparent candelas per lux per m<sup>2</sup> (foot candle per square foot) for glass beads when tested at an angle of incidence of 0° and a angle of divergence of 1/3°, shall not be less than 0.8.

 Flowing Properties. The glass beads shall flow uniformly through dispensing equipment in atmospheric humidity up to 94%. Type A. The beads shall be free of silicones, waxes, oils, or other coatings and pass the following test:

One hundred grams of glass beads, spread evenly and thinly in a suitable container, shall be conditioned at 25 °C (77 °F) for 4 hours over a solution of sulfuric acid (Sp. Gr. 1.10) in a closed desiccator. After 4 hours, the glass beads shall flow readily through a clean glass analytical funnel, 60 °, 75 mm (3 inch) diameter and 105 mm (4 inch) stem. Inside diameter of the stem shall be a nominal 6.3 mm (1/4 inch).

Type B. The beads shall have a silicone, moisture resistant coating and pass the following test:

One hundred grams of beads are placed in a 600 ml beaker and an equivalent volume of distilled water shall be added to the beaker. The beaker will then stand for 5 minutes, at the end of which time the water shall be carefully poured off and the beads transferred to a clean dry beaker and allowed to stand for 5 minutes. The beads will then be pured slowly into a standard glass funnel (Corning 6120), 127 mm. diameter, 1.02 mm. stem length and 11 mm. stem inside diameter. The beads shall flow through the funnel stem without stoppage. Slight initial agitation to start the flow through the funnel at the beginning of the test permissible.

c. Thermoplastic Compound. In the plastic state, the material shall remain constant and the material shall not deteriorate in any manner during reheating processes.

There shall be no obvious change in color of the material as a result of repeated heatings or from batch to batch. The maximum elapsed time after application after which normal traffic will leave no impression or imprint on the new stripe shall be 2 minutes at 10 °C (50 °F) or 10 minutes at 32 °C (90 °F) pavement temperature. After application and proper drying, the material shall show no appreciable deformation or discoloration, shall remain free from tack, and shall not lift from the pavement under normal traffic conditions within a road temperature range of -29 to 66 °C) (-20 to 150 °F). The stripe shall maintain its original dimensions and placement.

Cold ductility of the material shall be such as to permit normal dimensional distortion as a result of traffic impact within the temperature range specified.

The material shall provide a stripe that has a uniform thickness throughout its cross section and have the density and character to provide a sharp edge of the line.

The thermoplastic compound after heating for 5 hours at 218 °C (425 °F) and cooled at 25 °C (77 °F) shall meet the following requirements for daylight reflectance and color, when tested,

#### Pavement Markings

using a standard color difference meter (0°, 45°) and a magnesium oxide standard or an approved secondary standard.

White: Daylight Reflectance ...65 percent min. \*Yellow: Daylight Reflectance...45 percent min.

\*Shall match Federal Highway Color Tolerance Chart, PR Color No. 1

The material shall have not more than 0.5 percent by weight of retained water when tested by ASTM D 570, "Water Absorption of Plastics", Procedure (a).

The specific gravity of the compound at 25 °C (77 °F) shall be from 1.8 to 2.4. Specific gravity shall be determined according to ASTM D 153, Method A, using kerosene as the immersion liquid.

The softening point of the thermoplastic compound shall not occur at a temperature less than 93 °C (200 °F) as measured by the ball and ring method, ASTM E 28.

The bond strength shall have a minimum value of 1,030 kPa (150 psi).

## (3) Test Method.

- Apparatus.
  - 100 mm (4 in.) by 100 mm (4 in.) by 50-mm (2-in.) road course 24,000 kPa (3500 psi) concrete blocks brushed on one side.
  - Drawdown blade 50 mm (2 in) by 100 mm (4 in.) capable of applying a 0.003 mm (0.125 mil) dry film.
  - 3. Ovens.
  - 4. 50-mm (2 inches) by 50-mm (2 inches) steel blocks threaded in one end for 15.9-mm (5/8-inches). bolts.
  - 5. Spatulas for stirring, cutting, and shaping thermoplastic.
  - Two Component Epoxy or other suitable adhesive that will bind the metal block to the thermoplastic.
  - 7. Tensile tester.

## b. Procedure.

- Dry the concrete blocks in an oven at 105 °C (221 °F) overnight.
- Heat the thermoplastic material and drawdown blade to 204 °C (400 °F).
- Remove the drawdown blade from the oven, place on the brushed side of the concrete block, and make the drawdown

with the melted thermoplastic.

- Immediately place the two steel blocks on the thermoplastic film and trim the plastic from around the blocks. Remove the steel locks and allow the thermoplastic to cool for 24 hours.
- 5. Remove two steel blocks, which have been heated at 49 °C (120 °F) for two hours, from the oven, place a small amount of epoxy on the heated blocks and place on the thermoplastic squares, rubbing the steel blocks on the thermoplastic to ensure an even coating and good adhesion. Allow to cure overnight.
- Screw the 15.9-mm (5/8 inches) bolts into the steel blocks bonded to the thermoplastic and determine the bond strength in psi, using the tensile tester with a loading rate of 890 N/min. (200 lbs./min.)
- c. Freeze-Thaw Test. This test shall be identical to the Bond Strength Test through the setting of the epoxy. At this point the block shall be placed in a water bath to within 6.3 mm (1/4 inch) of the top of the block, but not over, for one hour and then placed in a freezing cabinet at -7 °C (20 °F) for 8 hours or more. The block shall be allowed to come to room temperature and the cycle shall be repeated 4 more times. After the five freeze-thaw cycles, the bond strength shall be determined. The minimum allowed value shall be 860 kPa (125 psi)
- (4) Identification. Each package of material shall be stenciled with the manufacturer's name, type of material, and IDOT specification number (IL 1095.01), the month and year the material was packaged, and the lot number. Lot numbers must begin with the last two digits of the year manufactured and be sequential beginning with Lot 1; i.e., the first lot manufactured in 1987 should be labeled 87-1. The letters and numbers used in the stencil shall be a minimum of 12.7 mm (1/2 inch) in height.
- (e) Sampling and Testing: All materials shall be sampled and tested according to the latest published standard methods of the American Society for Testing and Materials, and revisions thereof, in effect on the date of the invitation for bids. If there are no ASTM Standards which apply, applicable standard methods of the American Association of State Highway and Transportation Officials, or the Federal Government, of of other recognized standardizing agencies shall be used.

The right is reserved to inspect the material either at the place of manufacture and/or at the destination. If inspected at the place of manufacture, the manufacture shall furnish such facilities as may be required for collecting and forwarding samples, and shall also furnish facilities for testing the material during the process of manufacture, if required. Tests will be made by the Department at their expense. All material samples for acceptance tests shall be taken or witnessed by a representative of the Bureau of Materials and Physical Research at the manufacturer's plant and shall be submitted to the Engineer of Materials and Physical Research, 126 East Ash Street, Springfield, Illinois 62704, at least 30 days in advance of the pavement marking operations. Random check samples may be taken on the jobsite at the discretion of the

### **Pavement Markings**

Engineer.

The Engineer will test and certify the basic ingredients. The sample(s) shall be labeled as to the shipment number, if applicable, lot number, date, quantity and any other pertinent information. Samples shall be submitted in the following manner:

- (1) Glass beads: At least three randomly selected bags or containers shall be obtained from each lot or shipment of glass beads. The content of each bag or container shall be passed through a large Riffle Sampler, thus splitting the material down until a representative 1-liter (1-quart) sample is obtained. A 1-liter (1-quart) sample from each container shall be submitted in one full liter (quart) friction-top metal containers for testing.
- (2) Binder: 1 liter (quart)
- (3) Pigments: 1 liter (quart)
- (4) Filler: 1 liter (quart)
- (5) Thermoplastic:

At least 3 randomly selected bags shall be obtained from each lot. A 4.5 kg (10-lb.) composite sample of the 3 bags shall be submitted for testing and acceptance. The lot size shall be approximately 18,100 kg (40,000 lbs.) unless the total order is less than this amount.

(f) Manufacturer's Responsibility:

The Contractor shall only use material from manufacturers complying with the following:

- (1) The manufacturer shall perform tests on a minimum of one sample per 4,500 kg (10,000 lbs.) of thermoplastic produced. Minimum tests required shall be a softening point determination and color. Manufacturer's test results shall be submitted along with the thermoplastic sample to the Bureau of Materials and Physical Research. In addition, the manufacturer shall retain the test sample for a minimum period of 18 months.
- (2) The manufacturer shall furnish the Bureau of Materials and Physical Research with copies of bills of lading for all material inspected. Bills of lading shall indicate the consignee and destination, date of shipment, lot numbers, quantity, type of material, name, and location of source.
- (g) Material Acceptance:

Final acceptance of a particular lot of thermoplastic will be based on the following:

- (1) Compliance of ingredient materials with the specifications.
- (2) Compliance of thermoplastic material with the specifications.
- (3) Receipt of the Manufacturer's test results for each lot of thermoplastic.

(4) Identification requirements are met.

## (h) Notification:

The Contractor shall notify the Engineer 72 hours prior to the placement of the thermoplastic markings so an inspector can be present during the operation. At the time of this notification, the Contractor shall indicate the manufacturer and lot numbers of thermoplastic and glass beads he intends to use. The Engineer will ensure the approved lot numbers appear on the material package. Failure to comply with this provision may be cause for rejection.

- **1095.02 Paint Pavement Markings.** All materials shall meet the following paint and bead specifications unless a shortage of raw materials precludes the production of paint which will meet the materials portion of this section. If the shortage can be documented to the satisfaction of the Engineer, then an alternate formulation will be allowed. Any alternate formulation must comply with the Bureau of Materials specification M-123 or the latest acceptable alternate to this specification. Copies of these specifications may be obtained from the Engineer of Operations at (217) 782-3450.
  - (a) Ingredients. The ingredients used to manufacture the paint shall meet the following requirements:

TITANIUM DIOXIDE. This material shall comply with the latest revisions of the Specifications for Titanium Dioxide Pigments, ASTM D 476, Type II, Rutile. A notarized certificate of compliance from the pigment manufacturer shall be required.

YELLOW PIGMENT. This material shall be non-toxic organic pigment, Yellow 65, from one of the following sources:

Hoechst Celanese 11-2509-2RA Engelhard 1244 Sun Chemical 272-0065, or Cookson YT820D

CALCIUM CARBONATE. This material shall comply with the latest revision of the specifications for Calcium Carbonate Pigments, ASTM D1199, Type GC, Grade 1, with minimum of 95% Calcium Carbonate or Type PC, minimum 98% Calcium Carbonate.

ACRYLIC EMULSION POLYMER. This material shall be Rohm and Haas E-2706 or Dow Chemical DT-211.

METHYL ALCOHOL. This material shall comply with the latest revision of the Specification for Methyl Alcohol, ASTM D 1152.

MISCELLANEOUS MATERIALS.

Water: Potable

Dispersant: Tamol 901, or Tamol 850 (Rohm and Haas) or Colloids 226-35 (Rhone-Poulenc) or Nopcosperse 44 (Henkle)

Surfactant: Triton CF-10 (Union Carbide) or Colloids CTA 639 (Rhone-Poulenc)

Defoamer: Foamaster III or Foamaster PL (Henkel Corp.), Drew 493 (Drew Chemical) or Colloids 654 (Rhone-Poulenc)

Rheology Modifier: Natrasol 250 HBR (Aqualon Company) or Bermocoll E 431 FQ (Berol Kemi AB)

Coalescent: Texanol (Eastman Chemical)

Preservative: Troy 192 (Troy Chemical), Dowicil 75 (Dow Chemical) or Nuospet 101 (Hulls America) or Busan 1024 (Buckman Labs)

(b) Manufacture. All ingredient materials shall be delivered in the original containers and shall be used without adulteration.

The manufacturers shall furnish to the Department the batch formula which will be used in manufacturing the paint.

No change shall be made in this formula without prior approval by the Department and no change will be approved that adversely affects the quality or serviceability of the paint.

The following Standard Formulas shall be the basis for the paint. The finished products shall conform on a weight basis to the composition requirements of these formulas. No variations will be permitted except for the replacement of volatile lost in processing. Amounts are shown in kilograms (pounds) of material.

		<u>White</u>	Yellow
	C.I. Pigment Yellow 65 (Engelhard 1244)		14.52 (32)
	Titanium Dioxide, Rutile, Type II (Kerr-McGee CR800)	45.36 (100)	9.53 (21)
	Calcium Carbonate, Type PC (Mississippi M-60)	68.04 (150)	68.04 (150)
	Calcium Carbonate, Type GC (Hubercarb Q6)	195.05 (430)	210.92 (465)
	Rheology Modifier (Natrasol 250 HBR)	0.23 (0.5 *)	0.23 (0.5*)
	Acrylic Emulsion, 50% Solids (E2706)	245.40 (541)	242.68 (535)
	Coalescent (Texanol)	10.89 (24)	10.43 (23)
	Defoamer (Colloids 654)	2.27 (5)	2.27 (5)
	Dispersant (Tamol 850)	3.63 (8)	4.08 (9)
1	Surfactant (Triton CF 10)	0.91 (2)	0.91 (2)

Pavement Markings		Art. 1095.02	
Methyl Alcohol	13.15 (29)	12.70 (28)	
Preservative (Troy 192)	0.68 (1.5)	0.68 (1.5)	
Water	<u>4.54 (10)</u>	4.54 (10)	
Total. Kilograms (Pounds)	590.15 (1301)	581.53 (1282)	-

<sup>\*</sup>Rheology Modifier amount may be varied up to 0.05 kg (0.1 pound) to adjust viscosity to desired range.

(c) Properties. The finished paint shall meet the following requirements.

PIGMENT. Analysis of the extracted pigment shall conform to the following requirements:

		<u>White</u>	Yellow	
Organic Yellow 65	(%)		Min. 4.8	
Titanium Dioxide	(%)	Min. 13.4	Min. 2.8	
Calcium Carbonate	(%)	Max. 86	Max. 93	

The percent pigment by weight of the furnished product shall not be less than 50% nor more than 54%.

VEHICLE. The non-volatile portion of the vehicle shall be composed of a 100% acrylic polymer and shall not be less than 44% by weight.

ORGANIC VOLATILES. The finished paint shall contain less than 150 grams of volatile organic matter per liter of total paint. (ASTM D3960)

TOTAL SOLIDS. The finished paint shall not be less than 73% total non-volatile by weight. (ASTM D2369)

UNIT WEIGHT. The unit weight at 25 °C (77 °F.) of the production batches shall not vary more than plus or minus 0.036 kg/L (0.3 lbs. per gal.) from the weight of the qualification samples.

VISCOSITY. The consistency of the paint shall not be less than 83 nor more than 93 Krebs Units at 25  $^{\circ}$ C (77  $^{\circ}$ F.).

DRY OPACITY. The minimum contrast ratio shall be 0.97 when tested in accordance with Federal Specification, Method 141 a, No. 4121, Procedure B when applied at a wet film thickness of 0.38 mm (15 mils.).

COLOR AND DIRECTIONAL REFLECTANCE. The paint, applied at a wet film thickness of 0.38 mm (15 mils) and allowed to dry 24 hours, shall meet the following requirements for daylight reflectance and color, when tested, using a color spectrophotometer with 45° circumferential/0° geometry, illuminant C, and 2° observer angle. The color instrument shall measure the visible spectrum from 380 to 720 nm with a wavelength measurement interval and spectral bandpass of 10 nm.

White Daylight Reflectance (Y) 85 percent minimum

<sup>\*</sup>Yellow Daylight Reflectance (Y) 50 percent minimum

\*Shall match Federal 595 Color No. 33538 and chromaticity limit as follows:

X 0.490 0.475 0.485 0.530

Y 0.470 0.438 0.425 0.456

WATER RESISTANCE. The paint shall conform to Federal Specification TT-P-1952D, Section 3.2.5.

FREEZE-THAW STABILITY. The paint shall show no coagulation or change in consistency greater than 10 Kreb Units, when tested in accordance with Federal Specification TT-P-1952D, Section 4.3.8.

ACCELERATED PACKAGE STABILITY. The paint shall show no coagulation, discoloration, or change in consistency greater than 10 Kreb Units when tested in accordance with Federal Specification TT-P-1952D, Section 4.3.4.

DILUTION TEST. The paint shall be capable of dilution with water at all levels with out curdling or precipitation such that the wet paint can be readily cleaned up with water only.

STORAGE STABILITY. After 30 days storage in a three-quarters filled, closed container, the paint shall show no caking that cannot be readily remixed to a smooth, homogenous state, no skinning, livering, curdling or hard settling. The viscosity shall not change more than 5 Kreb Units from the viscosity of the original sample.

BLEEDING. The paint shall have a minimum bleeding ration of 0.97 when tested in accordance with Federal Specification TT-P-1952B, Section 4.5.13. The asphalt saturated felt shall conform to Federal Specification HH-R-590.

NO PICK-UP TIME. The no pick-up time shall be less than 10 minutes. The test shall follow the requirements of ASTM D 711 with a wet film thickness of 0.38 mm (15 mils).

GRIND. The paint shall have a grind of not less than 3 on a Hegman Grind Gauge.

FLEXIBILITY. The paint shall show no cracking or flaking when tested in accordance with Federal Specification TT-P-1952D, Section 4.3.4.

DRY THROUGH TIME. The paint, when applied to a non-absorbent substrate at a wet film thickness of 0.38 mm (15 mils) and placed in a humidity chamber controlled at 90  $\pm$  5% R.H. and a 22.5  $\pm$  1.4  $^{\circ}\text{C}$  (72.5 + 2.5  $^{\circ}\text{F}$ .) shall have a "dry through time not greater than 15 minutes of the IDOT standard formula. The dry through time shall be determined according to ASTM D 1640, except the pressure exerted shall be the minimum needed to maintain contact with the thumb and film.

NO TRACKING TIME FIELD TEST. The paint shall dry to a no-tracking condition under traffic in three minutes maximum when applied at 0.38  $\pm$  0.03 mm (15  $\pm$  1 mil) wet thickness at 54.4 - 65.6 °C (130 - 150 °F.), and from three to ten minutes when applied at ambient temperatures with 0.72 kg (6 pounds) of glass beads per liter (gallon) of paint. "No tracking" shall be the time in minutes required for the line to

withstand the running of a standard automobile over the line at a speed of approximately 64 km/hr (40 mph), simulating a passing procedure without tracking of the reflectorized line when viewed from a distance of 15 m (50 feet).

## (d) Beads

- (1) Properties. The glass beads for pavement marking furnished under this specification shall consist essentially of transparent, water-white glass particles of a spherical shape. They shall be manufactured from a glass of a composition designed to be highly resistant to traffic wear and to the effects of weathering. The glass beads shall be Type B and conform to the following requirements:
  - Sieve Analysis. The glass beads shall meet the following sieve requirement:

Sieve	U.S. Standard	Total Percent By
<u>Sizes</u>	Sieve No.	Mass (Weight) Passing
850 μm	20	100
600 μm	30	75-100
300 μm	50	15-40
150 μm	100	0-10
75 μm	200	0-2

- b. Imperfections. The surface of the glass beads shall be free of pits and scratches. The glass beads shall be spherical in shape and shall contain less than 20 percent by weight of dark particles or irregular shapes when tested by the standard method using a vibratile inclined glass plate.
- Index of Refraction. The index of refraction of the glass beads shall be not less than 1.50 when tested by the immersion method at 25 °C (77 °F).
- d. Silica Content. The glass beads shall contain at least 65 percent silica ( $SiO_2$ ).
- e. Chemical Stability. Glass beads which show tendency toward decomposition, including surface etching, when exposed to atmospheric conditions, moisture, dilute acids or alkalies, or paint film constituents will be rejected. The glass beads shall be tested by Federal Specification TT-B-1325A, Section 4.3.11, water resistance by soxhlet extraction method) with the following exceptions: Under "Procedure" the size of sample to be tested shall be 25 grams. Under testing Paragraph (1), the reflux-time shall be 5 hours and upon examination after testing, the glass beads shall show no dulling effect. Under Paragraph (2), if more than 4.5 mls. of 0.1N hydrochloric acid is used to reach the end point, it shall constitute failure of the test.
- f. Reflectivity. Beaded glass panels having a minimum reflective area of 116,000 mm<sup>2</sup> (180 sq. in.) shall be prepared in the following manner:

A standard white pavement marking paint, meeting the paint specifications included herein, shall be applied to the panels by

### **Pavement Markings**

means of a doctor blade to a wet film thickness of 0.38 mm (0.015 inch). After the paint has dried for approximately one minute, the glass beads shall be applied in a uniform layer in the proportion of 0.7 kg (6 lbs.) of glass beads to one liter (gallon) of paint. The panels shall be allowed to dry for approximately 24 hours before testing.

The coefficient of retroreflection (apparent candelas per lux per m<sup>2</sup> (foot candle per square foot) for glass beads when tested at an angle of incidence of 0° and a angle of divergence of 1/3°, shall not be less than 0.8.

- g. Flowing Properties. The glass beads shall meet the flow properties for Type B beads according to Article 1095.01(d).
- (2) Sampling and Testing

Sampling and testing shall be conducted according to Article 1095.01(f).

- **1095.03 Preformed Plastic Pavement Markings.** The material shall consist of white or yellow (as specified) weather resistant reflective film conforming to the requirements specified herein.
  - (a) Composition. The preformed plastic marking shall consist of high- quality plastic materials, pigments, and glass beads and shall be furnished with a pressure sensitive precoated adhesive.

The markings shall have the following minimum composition without adhesive:

<u>Components</u>	Minimum Percent By Weight
Resins and Plasticizers Pigment and Fillers Graded Glass Beads	20% 30% 25%

The remaining percentage shall be comprised of the above materials in various proportions.

- (b) Conformability and Resealing. The marking shall conform to pavement contours, breaks, faults, etc. through the action of traffic at all pavement temperatures. The film shall have resealing characteristics and shall be capable of fusing with itself or with previously applied marking material.
- (c) Thickness. Prior to application, the thickness of the material, without adhesive, shall be at least 1.50 mm (60 mils).

The Type B material shall feature and embossed pattern with a minimum thickness of 1.65 mm (65 mils) measured at the thickest point of the patterned cross section and a minimum of 0.508 mm (20 mils) measured at the thinnest point of the cross section.

(d) Durability and Wear Resistance. The markings, when properly applied, shall provide a neat, durable marking that will not flow or distort\ due to temperature if the pavement surface remains stable. The markings shall provide a cushioned resilent substsrate that reduces bead crushing and loss. The markings shall be weather resistant and, through normal traffic wear, show no appreciable fading, lifting, tearing, rollback, or other signs of poor adhesion.

(e) Skid Resistance. The surface of the markings shall provide the following minimum skid resistance values when tested according to ASTM E 303:

Type A	35 BPN
Type B	45 BPN
Type C	55 BPN

(f) Tensile Strength. The material shall have the following minimum tensile strength of cross section when tested according to ASTM D638-76 using a jaw speed of 250 to 300 mm (10 to 12 in.) per minute:

Type A	275 kPa (40 lbs./sq. inch)
Type B	Not Applicable
Type C	1,033 kPa (150 lbs./sq. inch)

(g) Elongation. The material shall have the following minimum elongation when tested according to ASTM D638-76 using a jaw speed of 250 to 300 mm (10 to 12 inch) per minute.

Type A	15%
Type B	Not Applicable
Type C	50%

(h) Glass Beads. Glass beads shall be uniformly distributed throughout the markings. A top coating of beads shall be bonded to or directly embedded into the surface of the markings in order to produce immediate retroreflectivity.

The glass beads shall be colorless and have a minimum index of refraction of 1.50 when tested using the liquid immersion method.

Type B material shall have an innermix of glass beads with a minimum index of refraction of 1.50 and a top coating of ceramic beads bonded to top urethane wear surface with a minimum index of refraction of 1.70. Beads with an index of refraction greater than 1.80 shall not be used.

Type C material shall have a layer of skid resistant ceramic particles bonded to the top urethane wear surface. The urethane wear surface shall have a nominal thickness of 0.13 mm (5 mils).

The bead adhesion shall be such that beads are not easily removed when the film is scratched firmly with a thumb nail.

- (i) Plastic Pull Test. A test specimen of 25 mm by 75 mm (1 in. by 3 in.) shall support a dead weight of 1.8 kg (four pounds) for not less than five minutes at a temperature between 21 and 27 °C (70 and 80 °F)
- (j) Pigmentation. The pigment for the white preformed plastic compound shall

### Pavement Markings

be a high grade pure (minimum 89 percent) titanium dioxide ( $TiO_2$ ). The white pigment content shall not be less than 10 percent by weight and shall be uniformly distributed throughout the compound.

The pigment used for the yellow preformed plastic compound shall be colorfast yellows, golds, and oranges. The yellow pigment content shall not be less than 3 percent by weight and shall be uniformly distributed throughout the compound.

(k) Color. The material shall meet the following requirements for daylight reflectance and color, when tested, using a standard color difference meter (0°, 45°) and a magnesium oxide standard or an approved secondary standard.

## Types A & B

White: Daylight reflectance, ....65 percent min. \*Yellow: Daylight reflectance,....45 percent min.

## Type C

White: Daylight reflectance, Y .....80% min.
\*Yellow: Daylight reflectance, .....36 yo 59% min.

(I) Reflectance. The white and yellow films shall have the following initial minimum reflectance values at 0.2° and 0.5° observation angles and 86.0° entrance angle as measured according to the testing procedures of Federal Test Method Standard 370. The photometric quantity to be measured shall be Specific Luminance (SL), and shall be expressed as millicandelas per m²). per lux (square foot per foot candle). The test distance shall be 15 m (50 ft.) and the sample size shall be a 300 mm by 600 mm 1.0 ft. x 2.0 ft.) rectangle. The angular aperture of both the photoreceptor and light projector shall be 6 minutes of arc. The reference center shall be the geometric center of the sample, and the reference axis shall be taken perpendicular to the test sample.



	<u>White</u>	Yellow
Observation Angle Specific Luminance	0.2° 0.5° 550 380	0.2° 0.5° 410 250
	Type C	
	<u>White</u>	Yellow
Observation Angle Specific Luminance	0.2° 0.5° 700 500	0.2° 0.5° 410 250

<sup>\*</sup>Shall match Federal Highway Color Tolerance Chart, PR Color No. 1 December 1972.

## Type B

	<u>White</u>	Yellow
Entrance Angle	86.5.°	86.5°
Observation Angle	1.0.°	1.0°
Specific Luminance	700	500

- (m) Identification. The material delivered to the jobsite shall be identified by the same shipment number(s), if applicable, batch or lot number(s), as the sample(s) tested and approved for that job. The batch or lot number(s) of the material, and the month and year the material is packaged, shall be stenciled or embossed on the container or included on the label.
- (n) Sampling and Testing. All material samples for acceptance tests will be taken or witnessed by a representative of the Bureau of Materials and Physical Research and will be submitted to the Engineer of Materials and Physical Research, 126 East Ash Street, Springfield, Illinois 62704. Random check samples may be taken at the jobsite at the discretion of the Engineer.

The Engineer will test and certify the basic requirements.

The Contractor shall provide the Enginer certification from the manufacturer that the material to be furnished meets all the requirements of these specifications.

Sample(s) of preformed plastic shall be a minimum of 0.2 square meters (2 square feet) of each color to be used.

The sample(s) shall be labeled with the shipment number(s), if applicable, batch or lot number(s), all batch number(s) comprising a lot, date, quantity, and any other pertinent information.

# **1095.04 Epoxy Pavement Marking.** All materials shall meet the following specifications:

- (a) The epoxy marking material shall consist of a 100 percent solid two- part system formulated and designed to provide a simple volumetric mixing ratio of two components (must be two volumes of Part A and one volume of Part B). No volatile or polluting solvents or fillers will be allowed.
- (b) The Epoxide Value (WPE) of Component A shall be 200-300 when tested according to ASTM D-1652 on a pigment free basis.
- (c) The Total Amine Value of Component B shall be 325-475 when tested according to ASTM D-2074.
- (d) Composition by Weight of Component A:

Pigment*	<u>White</u>	<u>Yellow</u>	
Titanium Dioxide ASTM D-476 Type II	21-24%		
Chrome Yellow ASTM D-211 Type III		23-26%	
Epoxy Resin	76-79%	74-77%	

<sup>\*</sup>No extender pigments are permitted.

### **Pavement Markings**

- (e) Upon heating to application temperature, the material shall not exclude fumes which are toxic or injurious to persons or property.
- (f) The daylight directional reflectanced of the cured epoxy (without glass spheres) shall not be less than 80% (white) and 50% (yellow) relative to magnesium oxide when tested in accordance with Federal Test Method Standard No. 141a, Method 6121. In addition, the color of the yellow epoxy shall visually match Color Number 33538 of Federal Standard 595a to the satisfaction of the Department.
- (g) The epoxy pavement marking material, when mixed in the proper ratio and applied at 0.35 mm to 0.41 mm (14 to 16 mils) wet film thickness and with the proper saturation of glass spheres, shall exhibit no tracking time of twenty minutes or more when tested according to ASTM D-711.

The catalyzed epoxy pavement marking materials when applied to a 50 mm (4 inch by 4 inch by 2 inch) concrete block, shall have a degree of adhesion which results in a 100 percent concrete failure in the performance of this test.

The concrete block shall be brushed on one side and have a minimum strength of 24,100 kPa (3500 psi). A 50 mm (2 inch) square film of the mixed epoxy shall be applied to the brushed surface and allowed to cure for 72 hours at room temperature. A 50 mm (2 inch) square cube is then affixed to the surface of the epoxy by means of an epoxy by means of an epoxy glue. After the glue has cured for 24 hours, the epoxy specimen is placed on a dynamic testing machine in such a fashion so that the specimen block is in a fixed position and the 50 mm (2 inch) cube (glued to the epoxy surface) is attached to the dynamometer head. Slowly apply direct upward pressure until the epoxy system fails. Record the location of the break and the amount of concrete failure.

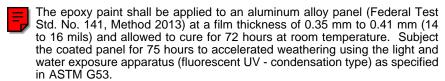
- (h) The epoxy pavement marking materials when tested according to ASTM D2240, shall have a shore D hardness of between 75 and 100. Films shall be cast on a rigid substrate at 0.35 mm to 0.41 mm (14 to 16 mils) in thickness and allowed to cure at room temperature for 72 hours before testing.
- (i) The abrasion resistance shall be evaluated on a Taber Abrader with a 1,000 gram load and CS 17 wheels. The duration of test shall be 1,000 cycles. The loss shall be calculated by difference and be less than 82 mgs. The tests shall be run on cured samples of material which have been applied at a film thickness of 0.35 mm to 0.41 mm (14 to 16 mils) to code S-16 stainless steel plates. The films shall be allowed to cure at room temperature for at least 72 hours before testing.
- (j) When tested according to ASTM D638, the epoxy pavement marking materials shall have a tensile strength of not less than 41,300 kPa (6,000 psi). The Type IV specimens shall be cast in a suitable mold not more than 6.3 mm (1/4 inch) thick and pulled at a rate of\ 6.3 mm (1/4 inch) per minute by a suitable dynamic testing machine. The samples shall be allowed to cure at room temperature for at least 72 hours before testing.
- (k) When tested according to ASTM 695, the catalyzed epoxy pavement marking materials shall have a compressive strength of not less than 83,000 kPa (12,000 psi). The cast sample shall be conditioned at room temperature for a minimum of 72 hours before performing the indicated

tests. The rate of compression of these samples shall 6.3 mm (1/4 inch) per minute or less.

- The glass beads shall meet the requirements of Article 1095.01(d) and the following requirements.
  - (1) The first drop glass beads shall meet the following five requirements.

Sieve <u>Size</u>	U.S. Standard Sieve Number	% Passing (By Weight)
1.70 mm	12	95-100
1.40 mm	14	75-95
1.18 mm	16	10-47
1.00 mm	18	0-7
850µm	20	0-5

- (2) The second drop glass beads shall meet the requirements of Article 1095.01 Type A.
- (3) The glass beads shall have a silane coating.



The cycle shall consist of 4 hours UV exposure at 50 °C (54 °F). At the end of the exposure period, the panel shall show no substantial change in color or gloss.

- (m) The material shall be shipped to the jobsite in substantial containers and shall be plainly marked with the manufacturer's name and address, the name and color of the material, date of manufacture, and batch number.
- (n) Prior to approval and use of the epoxy pavement marking materials, the manufacturer shall submit a notarized certification of an independent laboratory, together with the results of all tests, stating these materials meet the requirements as set forth herein. The certified test report shall state the lot tested, manufacturer's name, brand name of epoxy and date of manufacture. The certification shall be accompanied by one liter (one-quart) samples each of Part A and Part B. After approval by the Department, certification by the epoxy manufacturer shall be submitted for each batch used. New independent laboratory certified test results and samples for testing by the Department shall be submitted any time the manufacturing process or paint formulation is changed. All costs of testing (other than tests conducted by the Department) shall be borne by the Manufacturer.
- (o) Acceptance samples, shall consist of 2 one liter (one quart) samples of Part A and one liter (one quart) of Part B, of each lot of paint. The samples shall be submitted to the Department for testing, together with a manufacturer's certification. The certification shall state the formulation for the lot represented is essentially identical to that used for qualification testing. All acceptance samples shall be taken by a representative of the Illinois Department of Transportation. The epoxy pavement marking materials

shall not be used until tests are completed and they have met the requirements as set forth herein.

**1095.05 Preformed Thermoplastic Pavement Marking.** All materials shall meet the requirements of Article 1095.01 and the following specifications:

- (a) The preformed thermoplastic pavement marking film shall consist of resin, aggregates, pigments, binders, and glass beads which have been factory produced as a finished product supplied in a preformed state.
- (b) Glass beads shall be uniformly distributed throughout the entire cross sectional area. Immediate retroreflectivity can be provided by a preapplied layer of beads or by scattering surface beads on a molten material during application. The bead adhesion shall be such that beads are not easily removed when the material surface is scratched with a thumbnail.
- (c) The pavement markings shall contain a minimum of 30 percent graded glass beads by weight. The beads shall be clear and transparent and free of pits and scratches. Not more than 20 percent shall consist of irregular, fused spheroids, or silica. The index of refraction shall be not less than 1.50 when tested using the liquid immersion method.
- (d) The pavement markings shall have a minimum thickness of 3.15 mm (125 mils) as supplied by the manufacturer.
- (e) The pavement markings shall be capable of conforming to pavement contours, breaks, and faults through the action of traffic at normal pavement temperatures. The markings shall have resealing characteristics and shall be capable of fusing with itself and previously applied thermoplastic when heated with a propane blowtorch.
- (f) The pavement markings shall be resistant to deterioration due to the exposure to sunlight, water, oil, gasoline, salt, or adverse weather conditions.
- (g) The preformed thermoplastic markings shall not be brittle and must be sufficiently cohesive and flexible at temperatures exceeding 10 °C (50 °F) for one person to carry without the danger of fracturing the material prior to application.
- (h) The surface of the preformed thermoplastic markings shall provide a minimum skid resistance value of 45 BPN when tested according to ASTM: E303-74.
- (i) The preformed thermoplastic marking material shall have flexibility at 85° such that when a 63 mm by 150 mm (2 1/2 inch by 6 inch) sample is bent through an arc at 90° at a uniform rate in 10 seconds (9° per second) over a 25 mm (1 inch) mandrel, no cracking occurs in the test sample. The sample must be conditioned prior to testing at 29 + 1 °C (85 + 2 °F.) for a minimum of four hours. At least two specimens tested must meet the flexibility requirements at 29 °C (85 °F.) for a passing result.
- (j) Identification. The material shipped to the job site shall be identified by the same shipment number(s), if applicable, batch or lot number(s), as the sample(s) tested and approved for that job. The batch or lot number(s) of the material, and the month and year the material is packaged, shall be stenciled or embossed on the container or included on the label.

(k) Sampling and testing. All material samples for acceptance tests will be taken or witnessed by a representative of the Bureau of Materials and Physical Research, 126 East Ash Street, Springfield, Illinois 62704. Random check samples may be taken at the job site at the discretion of the Engineer.

The Engineer will test and certify the basic requirements.

The contractor shall provide the Engineer certification from the manufacturer that the material to be furnished meets all the requirements of these specifications.

Sample(s) of preformed plastic shall be a minimum 0.18 m<sup>2</sup> (2 sq. ft.) of each color to be used.

The sample(s) shall be labeled with the shipment number(s), if applicable, batch or lot number(s), all batch number(s) comprising a lot, date, quantity, and any other pertinent information. The sample(s) shall be labeled with the shipment numbers if applicable, batch or lot number(s) comprising a lot, date quantity and any other pertinent information.

**1095.06 Pavement Marking Tape.** White or yellow marking tape shall consist of glass spheres of high optical quality embedded into a binder on a suitable backing that is precoated with a pressure sensitive adhesive. The spheres shall be of uniform gradation and distributed evenly over the surface of the tape.

The material shall be white or yellow as specified. The colors shall conform closely to Federal color tolerances for pavement marking paint.



The white and yellow tape shall be readily visible when viewed under automotive headlights at night. Reflective values, measured according to the photometric testing procedures of ASTM E 809 shall be not less than those listed in the table below. The coefficient of retroreflection shall be expressed as average candelas per lux per m² (candelas per foot candle per sq. ft.) measured on a 600 x 300 mm (2 ft. x 1 ft.) panel at 86° incidence.

Reflective Values of Pavement Marking Type					
Types I & II		Type III			
Divergence	Coefficient of	f Retroflection	Divergence	Coeff. of Ref	troflection
Angle	White	Yellow	Angle	White	Yellow
0.2 0.5	0.20 0.18	0.18 0.16	0.2 0.5	0.10 0.09	0.09 0.08

The pavement marking tape shall have a precoated pressure sensitive adhesive and shall require no activation procedures. Test pieces of the tape shall be applied according to the manufacturer's instructions and tested according to ASTM D 1000, Method A, except that a stiff, short bristle roller brush and heavy hand pressure will be substituted for the weighted rubber roller in applying the test pieces to the metal

test panel. Material tested as directed above shall show a minimum adhesion value of 30 g/mm (750 g per inch) width at the temperatures specified in ASTM D 1000. The adhesive shall be resistant to oils, acids, solvents, and water, and shall not leave objectionable stains or residue after removal. The material shall be flexible and conformable to the texture of the pavement.

Type III tape shall be capable of performing for the duration of a normal construction season and shall then be capable of being removed intact or in large sections at pavement temperatures above 4 °C (40 °F.) either manually or with a roll-up device without the use of sandblasting, solvents, or grinding. The Contractor shall provide the Engineer certification, from the manufacturer of the Type III tape, that the material to be furnished meets the requirements for being removed after the following minimum traffic exposure based on transverse test decks with rolling traffic:

- (a) Time in place 400 days
- (b) ADT per lane 9,000 (28% trucks)
- (c) Axle hits 10,000,000 minimum

Samples of the material, applied to standard specimen plates will be measured for thickness, and tested for durability in accordance with Federal Test Method Standard No. 141A, Method 6192, using a CS-17 wheel and 1000-gram load, and shall meet the following criteria for minimum initial thickness and for durability, showing no significant change in color after being tested for the number of cycles indicated:



Test	Types I & II	Type III
Initial Thickness mm (Mils) Durability (Cycles)	White Yellow 5.1 (20) 5.1 (20) 5,000 5,000	White Yellow 5.1 (20) 5.1 (20) 1,500 1,500

The pavement marking tape, when applied according to the manufacturer's recommended procedures, shall be weather resistant and shall show no appreciable fading, lifting, or shrinkage during the useful life of the marking. The tape, as applied, shall be of good appearance, free of cracks, and edges shall be true, straight, and unbroken.

#### SECTION 1096. PAVEMENT MARKERS

**1096.01 Raised Reflective Pavement Markers.** Raised Reflective Pavement Markers shall meet the following specifications:

(a) The markers shall be low profile units consisting of an iron casting conforming to ASTM-A536-84, Grade 72-45-05 hardended to 52-54RC to which is attached a replaceable prismatic retroreflector for reflecting light from one or two directions as specified. The casting shall be shaped to deflect a snowplow blade upward, thus preventing damage to the reflectors. The bottom of the casting shall incorporate two parallel keels and a bow shaped web designed to fit into a a grooved road surface. The casting shall have leveling tabs to ensure proper embedment and shall be fastened to the road surface using an epoxy adhesive. The casting shall be designed

for bidirectional plowing. The casting shall be marked with the manufacturer's name and the model number of the marker shall be visible after installation.

- (b) The overall dimensions shall be approximately 254 mm (10 inches) long by 140 mm (5.5 inch) wide and a maximum of 45 mm (1.76 inch) high. The installed height shall be approximately 6 mm (0.3 inch) above the road surface. The surface of the keel and web shall be free of scale, dirt, rust, oil, grease, or any other contaminant which may reduce bond.
- (c) The reflector shall be of the prismatic type consisting of a methyl methacrylate or suitably compounded acrylonitrile bitadiene styrene (ABS) shell filled with a mixture of an inert thermosetting compound and filler material. The exterior surface of the shell shall be smooth and contain one (monodirectional) or two (bidirectional) methyl methacrylate prismatic reflector faces of the colors specified. The shell shall be fabricated in a manner that will provide a mechanical interlock between the thermosetting compound and the shell. The thermosetting compound shall bond directly to the backside of the metalized lens surface. The manufacturer's trademark shall be molded in the face of the reflector lens or on the reflector body so as to be visible after installation.



- d) The reflector lens shall be high-intensive type corner curb prismatic and shall provide total internal reflection of the light entering the lens face. The reflector shall fit securely into a recessed area on the upper surface on the marker casting web. The reflective surface of 1030 mm² (1.6 sq. inches) in area. The reflector shall have a scratch and abrasive resistant untempered glass coating bonded on the reflective surface(s).
- (e) The specific intensity of the reflective surface at 0.2 degrees divergence angle shall be as follows when the incident light is parallel to the base of the marker:

# Minimum Specific Intensity (candelas/lux (candelas/foot candle))

	Inciden	ce Angle
<u>Color</u>	<u>0°</u>	<u>20°</u>
Crystal	0.28 (3.0)	0.11 (1.2)
Amber	0.16 (1.8)	0.07 (0.7)

The marker color(s) shall be as specified in the plans.

# **1096.02 Temporary Raised Reflective Pavement Markers.** Temporary Raised Reflective Pavement Markers shall meet the following specifications:

- (a) The marker shall be of the prismatic type consisting of a methyl methacrylate or acrylonitrile bitadiene styrene (ABS) shell. The exterior surface of the marker shall be smooth and contain one (monodirectional) or two (bidirectional) methyl methacrylate cube corner prismatic reflector faces of the color specified. The cube corner prismatic reflectors shall either be molded within the marker or sonically sealed to the face of the shell. The manufacturer's trademark shall be molded either in the face of the reflector lens or on the shell so it is visible after installation.
- (b) The marker shall have a maximum height of 19 mm (0.75 inch), either

#### **Pavement Markers**

rectangular or octagonal in shape and a minimum 100 mm by 75 mm (4 inch by 3 inch) overall. The base of the marker shall be flat. The reflector face shall slope from the base toward the top of the marker. The reflective area of each face shall be a minimum of 225 mm<sup>2</sup> (0.35 sq.inch) and may be divided into no more than three separate segments.

- (c) The markers, without an adhesive pad, shall support a load of 450 kg (1,000 pounds). This shall be determined by centering a marker over the open end of a vertically-positioned hollow metal cylinder. The cylinder shall be 25 mm (1 inch) in height and have an internal diameter of 75mm (3 inch) and a wall thickness of 6.3 mm (0.25 inch). The load shall be applied slowly to the top of the marker through a 25 mm (1 inch) diameter by 25 mm (1 inch) high metal rod centered on top of the marker. Breakage or significant deformation of the marker shall constitute failure.
- (d) The marker shall have a finish and color that will not fade in ultraviolet conditions or be conducive to tire tracking and will provide good daytime delineation. The specific intensity of the reflective surface at 0.2 degrees divergence angle shall be as follows when the incident light is parallel to the base of the marker.

# Minimum Specific Intensity (candelas/lux (candelas/foot candle))

	Inciden	ce Angle
<u>Color</u>	<u>0°</u>	<u>20°</u>
Crystal Amber	0.90 (1.0) 0.06 (0.6)	0.04 (0.4) 0.02 (0.2)

The marker color(s) shall be as specified in the plans.

### **SECTION 1097. REFLECTORS**

**1097.01 General.** The reflectors shall be molded of acrylic plastic into a rectangular or trapezoidal shape designed to transmit a light pattern back toward the light source.

Reflectors shall be constructed of methyl methacrylate (acrylic) plastic and shall have a smooth face free of cracks and checks. The reflectors shall be the color specified in the plans and shall be ready for mounting. The manufacturer's trademark shall be molded in the face of the reflector lens or on the reflector body so it is visible after installation.



**1097.02 Prismatic Barrier Reflectors.** The unit shall have a minimum of 8500 mm<sup>2</sup> (9.0 sq. in.) of effective reflective area.

Reflectors shall conform to the following minimum specific intensities using the average values of three reflectors for each color:

# Minimum Specific Intensity (candelas/lux (candelas/foot candle))

Color	Incidence Angle $0^{\circ}$ $20^{\circ}$ $35$		
Crystal	5.6 (60)	5.1 (55)	0.8 (9)
Amber	3.3 (36)	3.1 (33)	0.5 (5)

**1097.03 Reflectors for Delineators.** The Contractor shall furnish, when requested to do so, a certification from the manufacturer stating that all reflectors conform to these requirements. The reflectors shall be furnished in either amber or crystal as specified and shall be ready for mounting. The plastic reflector units shall be free of cracks and checks, and fabrication shall be accomplished in a uniform and professional manner.

The reflectors shall be molded of methylmethacrylate plastic and have a clear, smooth and transparent lens (face) with a central mounting hole. The lens shall have a reflective area of not less than 4150 mm<sup>2</sup> (6.5 sq. inches) nor more than 7750 mm<sup>2</sup> (12.0 sq. inches) and shall be circular in shape. The manufacturer's trademark shall be molded in the face of the lens.

The rear surface of the lens shall provide reflectivity by a prismatic configuration such that it will affect total retrodirective internal reflection of light incident to the lens surface without the necessity of any plating or separate reflector.

The rear reflective surface of the lens shall be protected by a plastic coated metallic foil back or a separate plastic back fused to the lens under heat and pressure around the entire perimeter and the central mounting hole to form a unit permanently sealed against dust, water, and water vapor.

(a) Intensity. The coefficient of luminous intensity of each reflector shall be equal to or exceed the following minimum values regardless of reflector orientation.

Divergence	Entrance	Intensity	
Angle	Angle	Candelas/Lux	
Degrees	Degrees	(Candle Power per Foot Candle)	
		Crystal	Amber
0.1°	0°	11.0 (119)	6.6 (71)
0.1°	20°	4.4 (47)	2.6 (28)

- (b) Sealing. Submerge 5 reflectors in a water bath at room temperature. Subject the submerged samples to a vacuum of 125-mm (5-inch) gage for 5 minutes. Restore atmospheric pressure and leave the samples submerged for 5 minutes. The samples shall show no evidence of water intake.
- (c) Heat Resistance. Place 3 reflectors in a circulating air oven for 4 hours at 80 °C ± 3 °C (175 °F. ± 5 °F.). The reflectors shall be placed in a horizontal position on agrid or perforated shelf permitting free air circulation. At the conclusion of the test, the samples shall be removed from the oven and permitted to cool in air to room temperature. The samples shall show no significant change in shape and general appearance when compared

Art. 1097.03

#### Reflectors

with unexposed control standards.

- (d) Housings. One of the following types of housings shall be used:
  - (1) Type A. The back side of the reflector shall be protected by a plastic back fused to the lens under heat and pressure around the entire perimeter and the center mounting hole. The center mounting hole shall have an inside diameter of 5 mm (3/16 inch).
  - (2) Type B. The back side of the reflector shall be protected by a plastic coated metallic foil back, and be housed in 0.5 mm (0.020 inch) aluminum, formed to retain the reflector. The housing shall be provided with 4 embossed circular reinforcement ribs. An aluminum grommet with a 5 mm (3/16 inch) inside diameter shall be expanded within the reflector mounting hole.

### **SECTION 1100. EQUIPMENT**

#### **GENERAL**

#### SECTION 1101. GENERAL EQUIPMENT

All equipment utilized in the removal of roadway surfaces or waterproofing membranes shall meet, and shall be operated in compliance with a visual emission limitation of 30 percent opacity or Ringleman 1 for a period not longer than one minute and for not more than 4 minutes in the aggregate in any 60-minute period.

**1101.01 Rollers.** No roller shall be used that has in any way been thrown out of its original balance by the application of attachments not approved by the Engineer. All bearings shall be tight.

- (a) Pneumatic-Tired Rollers. The roller shall consist of not less than 9 pneumatic tires revolving on 2 axles. The tires on the front and rear wheels shall be staggered so that they will cover the entire area over which the roller travels. Under working conditions, the roller shall develop a compression of not less than 40 N/mm (225 lbs. per inch) width of tire tread.
- (b) Heavy Pneumatic-Tired Rollers. The roller shall have a gross mass (weight) of not less than 23 metric tons (25 tons) and shall consist of not less than 4 pneumatic-tired wheels revolving in one transverse line. The width of the roller shall be not less than 2.4 m (8 ft.), and it shall be constructed in 2 or more sections in such a manner that each section is free to oscillate or move independently. Under working conditions, the roller shall develop a compression of not less than 115 N/mm (650 lbs. per inch) width of tire tread.
- (c) Self-Propelled Pneumatic-Tired Roller. The roller shall be of the oscillating wheel type consisting of not less than 7 pneumatic-tired wheels revolving on 2 axles, and capable of being ballasted to the mass (weight) required.

The tires on the front and rear wheels shall be staggered so that the tire sidewalls will have a minimum overlap of 15 mm (1/2 inch). The roller shall provide for a smooth operation when starting, stopping or reversing direction. The tires shall withstand inflation pressures between 415 and 825 kPa (60 and 120 psi). The roller shall be equipped with an adequate scraping or cleaning device on each tire to prevent the accumulation of material on the tires. When used for the compaction of bituminous mixtures, the roller shall be equipped with a water system which will keep all tires uniformly wet to prevent material pickup when required.

The Contractor shall provide means for determining the mass (weight) of the roller as distributed on each wheel. Ballast shall be included in determining the mass (weight).

- (d) Tamping Rollers. The roller shall have a minimum mass (weight) of 15 N/mm (90 lbs. per inch) width of drum, and each individual tamper shall develop a compression of not less than 690 kPa (100 psi) of its tamping face area. The width of the tamping roller shall be not less than 2.4 m (8 ft.), and it shall be constructed in 2 or more sections in such a manner that each section is free to oscillate or move independently. It shall be equipped with cleaning teeth at the rear.
- (e) Steel Wheel Rollers. The roller shall be self-propelled, and provide a

### General Equipment

smooth operation when starting, stopping or reversing directions. The steering mechanism shall provide for positive control of the roller. Roller wheels shall be smooth and free from openings or projections which will mar the surface on which the roller is operated. Motor rollers shall be equipped with drip pans to contain oil, grease or gasoline drips generated by the roller operation. The roller shall be provided with adjustable scrapers which shall be used when necessary to keep the surface of the wheels clean.

When used on a bituminous surface, the roller shall be equipped with water tanks and sprinkling devices which shall be used when necessary to wet the wheels and prevent the bituminous mixture from sticking to them.

(1) Tandem Rollers. The Contractor shall provide means for determining the mass (weight) of the roller as distributed on each axle. Ballast shall be included in determining the mass (weight).

The rear wheel may be crowned at the rate of not more than 5 mm in 1.4 m (3/16 inch in 4 1/2 ft.). The front wheel shall be divided into at least 2 sections and shall show no noticeable crown. The mass (weight) of the roller shall conform to that required in the specific item of work being constructed.

- (2) Three Wheel Rollers. The rear wheels of three wheel rollers may be crowned at the rate of not more than 2 mm in 500 mm (1/16 inch in 20 inches) and shall be propelled with a differential gear. The front wheel shall be divided into at least 2 sections, shall show no noticeable crown, and shall overlap the compression area of each rear wheel by not less than 38 mm (1 1/2 inches). The mass (weight) of the roller shall conform to that required in the specific item of work being constructed.
- (f) Trench Roller. The roller shall be a self-propelled, and provide a smooth operation when starting, stopping or reversing directions. The width of the compaction roller shall be not less than 500 mm (20 inches). The diameter of the compaction roller shall be not less than 1500 mm (60 inches). The roller wheels shall be smooth and free from openings or projections which will mar the surface on which the roller is operated. Motor rollers shall be equipped with drip pans to contain oil, grease or gasoline generated by the roller operation. The roller shall be provided with adjustable scrapers which shall be used when necessary to keep the surface of the wheels clean.

When used on a bituminous surface, the roller shall be equipped with water tanks and sprinkling devices which shall be used when necessary to wet the wheels and prevent the bituminous mixture from sticking to them.

The mass (weight) of the roller shall conform to that required in the specific item of work being constructed. The Contractor shall provide means for determining the mass (weight) of the roller as distributed on the compression wheel. Ballast shall be included in determining the mass (weight).

The balance wheel of the roller shall be adjustable in height to provide the slope of the surface of the specific item of work being constructed.

(g) Vibratory Roller. The vibratory roller shall be self-propelled and provide a smooth operation when starting, stopping or reversing directions. The vibrating drum(s) amplitude and frequency shall be approximately the same in each direction and meet the following minimum requirements: drum diameter 1200 mm (48 inches), length of drum 1675 mm (66 inches), vibrators 1600 vibrations per minute (VPM), unit static force on vibrating drum(s) 22 N/mm (125 lbs. per inch), total applied force 57 N/mm (325 lbs. per inch), adjustable eccentrics, reversible eccentrics on nondriven drum(s). The total applied force for various combinations of VPM and eccentric positions shall be shown on decals on the vibrating roller or on a chart maintained with the roller. The vibratory roller shall be equipped with water tanks and sprinkling devices, or other approved methods, which shall be used when necessary to wet the wheels to prevent the bituminous mixture from sticking to them.

A vibrating reed tachometer (hand type) shall be furnished with each vibratory roller. The vibrating reed tachometer shall have a range of 1000 to 4000 VPM. The vibrating reed tachometer shall have two (2) rows of reeds, one ranging from 1000 to 2000 and the other 2000 to 4000 VPM.

- **1101.02 Disk Harrow.** The disk harrow shall be the tandem type and shall meet the approval of the Engineer prior to its use. It shall be of sufficient size and mass (weight) to perform the manipulation required.
- **1101.03 Mechanical Sweeper.** The sweeper shall be constructed in a manner which will permit the revolutions of the broom to be adjusted in relation to its progression and permit the adjustment of the broom in relation to the surface being cleaned. It shall be supplied with sufficient extra or repair parts to prevent delay. The broom bristles shall be stiff enough to sweep clean without cutting into the surface. A broom with steel bristles will not be permitted.
- **1101.04 Mechanical Tamper.** The mechanical tamper shall be of a type required to obtain the specified compaction.
- **1101.05 Motor Grader.** The motor grader shall be self-powered and equipped with an adjustable mold board. The cutting blade shall be straight and in good condition. There shall be a minimum of play in the blade operating mechanism.
- **1101.06 Rotary Speed Mixer.** Rotary speed mixers shall be either the power takeoff or the self-powered type, equipped with a hydraulic lift. Worn scarifying and mixing parts shall be replaced and extra parts shall be available for replacement.
- **1101.07 Traveling Mixing Plant.** All traveling mixing plants shall meet the approval of the Engineer. The plants shall be either of the type which will pulverize the material to be treated and mix the material and cement with the proper amount of water without picking the materials up from the roadway, or of the pugmill type which elevates the material into a pugmill for mixing. The plant shall be equipped with a device which will accurately control and measure the quantity of water used. Worn scarifying and mixing parts shall be replaced and extra parts shall be available for replacements.
- **1101.08 Seeding Equipment.** If the Contractor elects to use the following equipment, it shall meet the following requirements:
  - (a) Disk. The disk shall meet the approval of the Engineer and have sound unbroken blades, which have a minimum diameter of 375 mm (15 inches). The disk shall be weighted, if necessary, to obtain the required tillage depth of 75 mm (3 inches).

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- (b) Slope Harrow. Slope harrows shall consist of a rolling mass (weight) attached by heavy chain to a tractor. The chain shall be of a suitable length, shall have picks welded to the links, and shall have a means of rotating the picks as the rolling mass (weight) is pulled in a direction parallel to the movement of the tractor.
- (c) Hydraulic Seeder. When hydraulic seeders are used, the inoculant and seed required shall be applied in a single operation.
  - Hydraulic seeding equipment shall include a pump rated and operated at no less than 375 L (100 gals.) per minute and no less than 690 kPa (100 psi) pressure. The tank shall have a mechanical agitator powerful enough to keep the seed and fertilizer in a uniform suspension in the water.
- (d) Cultipacker. The roller or cultipacker shall have rollers at least 300 mm (12 inches) in diameter and shall be of sufficient mass (weight) to pulverize the clods of soil. A double gang style shall be used.
- (e) Spinning Disk Seeders. When spinning disk seeders are used, the individual seeds comprising the seeding mixture shall be sown separately excepting fescue and perennial rye grass, which may be sown together.
- (f) Tractor Drawn or Mounted Seeders. These seeders shall be pulled by mechanical means, have an adjustable gate opening providing uniform flow of width adapted to the work, and drop the seed directly into place on the prepared seedbed. The seeder may be of a type mounted on cultipacker rollers which covers the seed and rolls the seedbed in one operation.
- (g) Rangeland Type Grass Drill and Interseeding Attachment. These seeders shall be designed specifically for the seeding of native prairie grasses and shall be approved by the Engineer prior to use. When seeding over existing turf, the rangeland type grass drill shall be equipped with a no-till interseeding attachment that is capable of cutting a slit in the soil free of leaves and debris, placing the seed in the slit, and compacting the seed into the soil of the slit.
- (h) Slit Seeder. These seeders shall be self-propelled or tractor-drawn and shall be designed specifically for no-till interseeding of turf grass seed into existing turf. The slit seeder shall be capable of performing the operations specified above in (g) for the interseeding attachment.

#### 1101.09 Membrane Curing Equipment.

(a) Equipment for applying membrane curing shall meet the following requirements when the pavement width is 3 m (10 ft.) or more. For lesser widths and for variable width pavement, the equipment shall meet the requirements of Article 1101.09(b). For the application of membrane curing compound, the mechanical equipment shall be self-propelled and shall be operated upon the pavement forms or, when a slip-form paver is used, upon the subgrade immediately adjacent to the edges of the pavement. The spraying equipment shall consist of a container having a capacity of not less than 95 L (25 gals.) in which a constant pressure can be maintained by mechanical means, or a suitable pumping arrangement in order that a constant pressure at the spray nozzles will be maintained so that the membrane curing compound will be applied uniformly at the specified rate. The spray unit shall be rigidly attached and shall be equipped with mechanical devices providing constant agitation of the membrane curing

compound and continuous circulation of the compound between the container and the spray nozzles. The spray nozzles shall be attached to a distributor pipe so the spray will be applied vertically from not more than 600 mm (2 ft.) above the surface of the pavement, and their horizontal spacing shall be such that uniform coverage of the pavement surface will be obtained. The nozzles shall be designed so they will deliver a uniform fine spray and so that they can be easily cleaned. A suitable shield or apron shall be provided to effectively protect the spray from wind. Sufficient nozzles shall be on hand at all times so that any inefficient nozzle can be immediately replaced. Suitable means of cleaning and repairing nozzles shall also be on hand and shall be considered as being part of the spraying equipment.

- (b) The equipment used to apply membrane curing compound to variable widths of pavement and other concrete construction where permitted, may be equipped with a container having not less than 20 L (5 gals.) in which a constant pressure shall be maintained by a mechanical means.
- (c) The equipment used to apply membrane curing compound to pavement widening shall meet the requirements of paragraph (a), except the equipment as a whole shall be mounted on a vehicle traveling on the existing pavement.
- (d) The equipment used to apply membrane curing compound to bridge floors shall consist of a container having a minimum capacity of 95 L (25 gals.) in which a constant pressure is maintained by mechanical means to insure the membrane curing compound is applied uniformly at the specified rate. The spray nozzle or nozzles shall be designed to deliver a uniform fine spray and be easily cleaned, should they become clogged. A separate construction bridge spanning the width of the deck being placed shall be provided for the spraying operation. Exposed reinforcing steel and construction joint areas shall be covered or shielded to prevent curing compound from coating any portions of these surfaces.

### 1101.10 Pavement Surface Test Equipment.

- (a) 5 m (16 ft.) Straightedge. The 5 m (16 ft.) straightedge shall consist of a metal I-beam mounted between 2 wheels spaced 5 m (16 ft.) between the axles. Scratcher bolts which can be easily and accurately adjusted, shall be set at the 1/4, 1/2, and 3/4 points between the axle. A handle suitable for pushing and guiding shall be attached to the straightedge. The straightedge shall meet the approval of the Engineer.
- (b) California Profilograph. The California profilograph or approved equivalent shall consist of a frame 7.5 m (25 ft.) in length supported upon multiple wheels at either end. The profile shall be recorded from the vertical movement of a wheel attached to the frame at mid point. The profile shall be recorded on a scale of 1:300 horizontally and 1:1 vertically. The profilograph shall be available to the Engineer before paving operations commence, be in working order ready to operate at time of delivery, and meet the following requirements:
  - (1) The profile wheel shall not be out of round or excessively worn.
  - (2) No frame alignment pins shall be missing and there shall be no appreciable movement of frame joints.
  - (3) The carriage wheels shall not be excessively worn.

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- (4) The steering rods shall be straight and all joints shall be tight when assembled.
- (5) The rear wheels shall track the front wheels within 150 mm (6 inches).
- (6) The horizontal scale on the profile shall check within 600 mm (2 ft.) in 30 m (100 ft.) (minimum calibration length shall be 60 m (200 ft.). The vertical scale shall be true scale.
- (7) An adequate supply of recorder pens and profile paper for the type of recorder unit furnished shall be provided.
- (8) A reference marker shall be provided for guiding the profilograph along the profile lines 1 m (3 ft.) from and parallel to the edge of pavement. The reference marker shall be reversible.
- **1101.11 Hydrodemolition Equipment.** The equipment shall consist of filtering and pumping units operating with a remote-controlled robotic device. The equipment shall be capable of removing concrete to the specified depth and of removing rust and concrete particles from exposed reinforcing bars.
- **1101.12 Cleaning.** The equipment shall be of sufficient size and capacity to efficiently and economically clean the roadway surface to the specified cleanliness. Equipment shall be power driven and in good operating condition. Equipment shall utilize moisture and oil traps, in working order, of sufficient capacity to prevent contamination of the roadway surface.
- 1101.13 Portable Shot Blast Equipment. The portable shotblast equipment shall use recyclable steel shot as an abrasive and shall include a dust collection system to provide for a dust free operation. Equipment shall utilize moisture and oil traps, in working order, of sufficient capacity to remove contaminants from the air and prevent oil or other contaminants from being deposited on the roadway surface. The equipment shall have an adequate air-cooled power source with a heavy duty hydrostatic transmission for variable speed operation, a variable abrasive valve for controlling the depth of cut, a small turning radius for manuverability and a single switch one man operation with forward and reverse capabilities. The equipment shall have an operating speed of 0-50 meters (0-160 feet) per minute and a forward and reverse travel speed of 0-105 meters (0-350 feet) per minute. The shot feed rate shall be variable from 0-320 kg (0-700 pounds) per minute and the shot hopper shall have a capacity of 90 kg (200 pounds).



#### **SECTION 1102. BITUMINOUS EQUIPMENT**

1102.01 Hot-Mix Plant. The hot-mix plant shall be the batch-type, continuous-type, or drier drum plant. The plants shall be evaluated for prequalification rating and approval to produce Class I mixtures according to the Bureau of Materials and Physical Research Policy Memorandum, "Approval of Hot-Mix Bituminous Plants and Equipment." The plants shall not be used to produce mixtures concurrently for more than one project or for private work unless permission is granted in writing by the Engineer. The plant units shall be so designed, coordinated and operated that they will function properly and produce bituminous mixtures having uniform temperatures and compositions within the tolerances specified. The plant units shall meet the following requirements:

- (a) General Requirements for All Plants.
  - (1) General. The plant shall be approved before production begins. It shall be equipped with adequate and safe stairways to the mixer platform and sampling points. Guarded ladders shall be placed at all points where accessibility to plant operations is required. Accessibility to the top of truck beds shall be provided by dual platforms or other suitable device to enable the Engineer to obtain samples and mixture temperature data. A hoist or pulley system, if required by the Engineer, shall be provided to raise scale calibration equipment, sampling equipment and other similar equipment from the ground to the mixer platform and return. All gears, pulleys, chains, sprockets and other dangerous moving parts shall be thoroughly guarded and protected. Ample and unobstructed space shall be provided on the mixing platform. A clear and unobstructed passage shall be maintained at all times in and around the truck loading area. This area shall be kept free from drippings from the mixing platform. The plant shall be equipped with an approved dust collecting system.

All aggregate feeders shall be calibrated to the desired volumes and/or weights for each aggregate/mixture, to the satisfaction of the Engineer. This calibration may require plant modification. Hot aggregate bins in batch or continuous plants shall not be modified in any manner. All batch and continuous plants approved after April 1, 1994, shall utilize a minimum of 4 hot bins when producing Class I Binder Mixes.

# (2) Laboratory.

The plant laboratory shall have approximately  $20~m^2$  (200~sq.~ft.) of floor for performing the necessary tests for control of the mixture. The room shall be provided with sufficient heat, natural and artificial light, air conditioning, and be equipped with a desk, chair, drafting stool, work bench  $0.9 \times 3 \times 0.9~m$  ( $3 \times 10 \times 3'$ ) high with drawers and cabinets below, service sink and water supply and 110 volt outlets. First aid equipment, telephone (for exclusive use by the Engineer) and fire extinguisher having a minimum Underwriters Laboratory rating of 2A1OBC and sanitary facilities shall be available.

When approved by the Engineer, a room with sufficient space for performing the necessary tests for control of the mixture, either in a building occupied by the bituminous concrete operator or in a separate building satisfactory to the Engineer, may be substituted for the aforementioned facility.

Plants producing Class I bituminous mixtures in any quantity or producing other bituminous mixtures totaling 2250 metric tons (2500 tons) or more for a particular job shall be supplied with the following equipment meeting the approval of the Engineer:

- 1 Hot plate
- 1 Eureka testing outfit for density test
- 1 Balance and weights (approximately 2.5 kilograms capacity) with an accuracy to 0.1 grams
- 1 Set of sieves 37.5 mm (1 1/2"), 25 mm (1"), 19 mm (3/4"), 12.5 mm (1/2"), 9.5 mm (3/8"), 4.75 mm (No. 4), 2.36 mm (No. 8), 2.00 mm (No. 10), 1.18 mm (No. 16),

 $600~\mu m$  (No. 30),  $425~\mu m$  (No. 40),  $300~\mu m$  (No. 50),  $180~\mu m$  (No. 80),  $150~\mu m$  (No. 100),  $75~\mu m$  (No. 200), pan and lid

1 Mechanical sieve shaker and timer

1 Oven of approximately 0.2 m<sup>3</sup> (6 cu. ft.) with a controllable range from room temperature to 175 °C (350 °F.)

2 Sample splitters (1 for coarse aggregate and 1 for fine aggregate) and 3 pans

6 Small drying pans (approx. 215 mm (8 1/2") dia.)

1 600 watt, 0.03 m<sup>3</sup> (1 cu. ft.) microwave (drier drum plant only)

The Engineer may accept alternate equipment proposed by the Contractor provided the substituted equipment performs the same quality assurance function.

- (3) Storage Facilities. The plant used in the preparation of the bituminous mixtures shall be located where it will have adequate storage and transportation facilities. Sufficient space shall be provided for separate stockpiles of each size of aggregate required. If necessary to prevent the intermixing of the different materials, or if stockpiles join together, suitable partitions shall be used between adjacent stockpiles. In general, the fine aggregates to be used in the bituminous mixtures shall be placed in separate stockpiles before they are placed in the cold aggregate bins. All aggregates shall be kept separated until they are fed in their proper proportions onto a belt conveyor or into the boot of the cold aggregate elevator. The aggregates shall be handled in such a manner as to prevent contamination, degradation and segregation.
- (4) Crane or End Loader. The crane used in stockpiling the aggregates or conveying the aggregates to the aggregate feeders shall be in first-class mechanical condition. When compartment aggregate feeders are used, the width of the crane bucket shall be not more than 1/2 the minimum width of the top of the bin compartments, and the maximum length of the bucket when fully open shall be at least 300 mm (1 ft.) less than the length of the top of the bin compartment. When an end loader is used to charge the cold bins, the maximum discharge width of the bucket shall be 600 mm (2 ft.) less than the width of the top of the bin compartment.
- (5) Aggregate Feeders. The plant shall be provided with accurate mechanical means for uniformly feeding each aggregate in its proper proportion into the drier so that uniform production and uniform temperature will be obtained. The controls of the total quantity of combined aggregates fed to the drier shall be by a variable speed system. Other methods may be approved by the Engineer. All gates shall be capable of being locked or bolted securely in required position. A minimum of 4 bins and feeders will be required. All aggregate feeders shall be calibrated to the desired volumes and/or weights for each aggregate/mixture, to the satisfaction of the Engineer. This calibration may require plant modification.
- (6) Driers. The plant shall be equipped with a revolving cylindrical drier or driers capable of heating and drying all of the aggregates to the temperatures required when the plant is operating at the full rated capacity.

(7) Dust Collection. The plant shall be equipped with a primary (cyclone) dust collector connected to a secondary dust collector (baghouse or wet-wash). The contents of each collector shall not be stored internally but shall be discharged directly into a separate hopper or silo for temporary storage and/or distribution into the mixture. In no case will intermingling of primary and secondary dust in the same hopper or silo be permitted.

The requirement for a cyclone collector may be waived, provided that the baghouse is equipped internally with a "knock-out box" capable of performing the same function as a primary collector.

Material collected in the primary collector shall discharge into a hopper which is equipped with the means of either wasting stored dust or metering and conveying its contents into the boot of the hot elevator. Metering of dust from the hopper shall be accomplished by either an adjustable variable speed vane or auger feeder. Feed shall be actuated by a control located in the discharge chute between the drier and the hot elevator, and shall only occur when aggregate is being discharged from the drier. In all cases, the hopper used for storing the primary material shall be equipped with a low-bin indicator.

Material collected in the bag portion of the baghouse shall not be stored internally but shall be discharged directly into a silo for storage and/or feed into the mixture. Feed of such stored material into the mix shall be accomplished only by mass (weight).

(8) Screens. The screens used in separating the aggregates shall be of the vibrating types, and when operated at normal speeds shall separate the aggregates satisfactorily. The screening system shall be equipped with a scalping screen having openings not more than 13 mm (1/2 inch) larger than the largest size aggregate used in preparing the bituminous mixture. The screening system shall have a tailing pipe for the removal of oversized aggregate. The discharge point of the tailing pipe shall be located so that it will not create a hazard or nuisance. The screens shall produce aggregate in the proper bins, as required.

Efficiency of separation based on laboratory sieves, shall be such that no more than 20 percent of the material in the bin is smaller than the nominal size nor more than 10 percent over size for that bin.

(9) Hot Aggregate Bin. The plant shall include storage bins of sufficient capacity to supply the mixer when it is operating at full capacity. Bins shall be arranged to assure separate and adequate storage of appropriate fractions of the mineral aggregates. Separate dry storage shall be provided for mineral filler, and the plant shall be equipped to feed the material into the mixer. Each bin shall be provided with overflow pipes, of such size and at such locations as to prevent backing up of material into other compartments or bins. Material from the overflow pipe shall not be returned to the hot elevator. Each compartment shall be provided with its individual outlet gate, constructed so that when the gate is closed or the feeder is stopped, there will be no leakage. Batch plant gates shall cut off quickly and completely. Bins shall be so constructed that samples can be readily obtained. A sampling device having the same width as the hot

- aggregate bin outlet gates shall be provided for this purpose. Hot aggregate bins in batch or continuous plants shall not be modified in any manner nor shall divider plates be removed.
- (10) Hot-Mix Surge Bins. The Contractor may use a hot-mix surge system in the manufacture of bituminous mixes provided the bin(s) meet the following requirements and are operated to the satisfaction of the Engineer. The complete surge system shall be designed and operated to prevent segregation and loss of temperature of the mix. Maximum retention time shall be 8 hours unless longer retention time is authorized in writing by the Engineer. The bin(s) shall be insulated and/or heated, and of an enclosed weatherproof type. A combination low level indicator and cutoff system shall be provided that will automatically stop the discharge of mix from the surge bin(s) when the mix falls below the top of the discharge cone. An alarm system, audible to personnel in the immediate plant area, shall be provided to sound automatically when the above system is bypassed. The conveying system used to transport the mix from the pugmill to the bin(s) may be a continuous type or skip bucket type. The continuous type shall be enclosed, heated and/or insulated for effective control of mix temperature. The skip bucket must have sufficient capacity to transport an entire batch and mass dump into bin(s). Means must be provided to discharge the mix into trucks, either from the pugmill or by a diversion device, when required.

No surge system will be approved by itself but shall be considered as part of a complete operating hot-mix plant. The mix as discharged from the bin(s) shall meet all Specification requirements for the mix being produced. Approval for the use of a surge system may be withdrawn at anytime, by the Engineer, for unsatisfactory operation.

- (11) Temperature Recording Instrument. The plant shall be equipped with either a recording pyrometer or a recording thermometer having at least 2 terminals when a single drier is used, and at least 3 terminals when a dual drier is used. The type and accuracy of the recording instrument shall be approved by the Engineer. Unless otherwise approved, one terminal shall be installed at a suitable location at the discharge of each drier and the others near the discharge gate in each bin compartment used for fine aggregate. The temperature recording instrument shall be capable of making accurate charts of the temperatures during the day's run. The recording instrument shall be installed at a point free from the dust and vibration of the plant. If this instrument is not located as to indicate clearly to the drum fireman the temperature of the mineral aggregates at the discharge of each drier, a non-recording pyrometer shall also be installed in view of the At the end of each day's run, the record sheet of the recording instrument shall be submitted to the Engineer.
- (12) Storage Tanks for Bituminous Materials. Tanks for the storage of bituminous material shall be equipped to heat and hold the material at the required temperatures. The heating shall be accomplished by steam coils, hot oil coils, electricity or other approved means so that no flame shall be in contact with the tank. All asphalt lines and fittings shall be steam, electric or hot oil jacketed. Provisions shall be made for sampling the asphalt from the line leading to the weigh bucket or metering device. If more than one grade of bituminous material is

required for concurrent operations, adequate storage and separate piping to the weigh bucket or metering device for each grade, or other methods approved by the Engineer that prevent intermingling of the asphalts, shall be provided. An armored thermometer or pyrometer which will accurately show temperatures between 95 and 205 °C (200 and 400 °F.) shall be suitably located in the asphalt line or within the tank. The instrument shall be located so as to indicate to the fireman or weighing operator, the temperature of the bituminous material.

- (13) Equipment for Weighing Bituminous Mixtures. Platform scales, surge bin scales or surge bin hopper scales used to weigh bituminous mixtures shall be equipped with automatic printers. The automatic printer shall be an integral part of the scale equipment or the scale and printer shall be directly connected in a manner that will prohibit the manual entry of weights except as provided in a, below.
  - a. If the platform scale equipment measures gross mass (weight), the printer will record the gross mass (weight) as a minimum.
     Tare and net masses (weights) shall be shown on weigh tickets and may be printed automatically or entered manually.
  - If scale equipment on a platform scale zeros out the truck tare automatically, the printer shall record the net mass (weight) as a minimum.
  - c. If the scale equipment on a surge bin weigh hopper zeros automatically after discharging each batch, the printer shall record the net mass (weight) as a minimum.
  - d. If the scale equipment on surge bins automatically shuts down the feed system and weighs the amount in the silo before and after discharge, the printer shall record the net mass (weight) as a minimum.

The automatic printer shall produce a weight ticket in triplicate. Masses (Weights) shall be shown in kilograms (pounds) to the nearest 0.01 metric ton (0.01 ton).

- (14) Test Measurements. Ten standard 25 kg (50 lb.) weights meeting the requirements of the U. S. Bureau of Standards shall be available on the job site for use in calibrating and testing the weighing equipment. The weights will not be required when the scales are calibrated by reputable, trained scale personnel with adequate scale testing equipment and the calibration is observed by the Engineer.
- (b) Special Requirements for Batching Plants.
  - (1) Equipment for Weighing or Measuring Aggregate. The equipment shall include a means for accurately weighing each size of aggregate in a weigh box or hopper suspended on scales and of ample size to hold a full batch without hand raking or running over. The gate shall close tightly so that no material is allowed to leak into the mixer while a batch is being weighed.

If the aggregates are measured by volume in calibrated compartments, the calibrated compartments shall form the weigh hopper and shall be arranged so that the volume measurement of each compartment and each batch may be checked by mass (weight). The means of checking the volume measurement shall meet the approval of the Engineer. RAP material shall be weighed prior to entering the pugmill.

The scale shall be a springless dial scale complying with the requirements of Article 1103.02(c). Load cells with digital readouts may be used if approved by the Engineer. The scale shall have a capacity of not more than twice the mass (weight) of the approved capacity of the mixer.

- (2) Mineral Filler Elevating System. The mineral filler shall be weighed in the aggregate weigh hopper or measured by volume in a calibrated compartment. It shall be conveyed to the weigh hopper by approved means. The mineral filler feeding system shall be so arranged that the accuracy of feed will not be affected by the head of material in the mineral filler bin. The conveyor shall operate in such manner as will enable small fractions of the material to be weighed. The chute used to introduce the mineral filler into the weigh hopper shall be so constructed that none of the material is retained in it after the required amount has been deposited in the weigh hopper.
- (3) Equipment for Weighing or Measuring Bituminous Material. The equipment used for weighing or measuring the bituminous material shall consist either of an approved weigh bucket or metering device. If a weigh bucket is used, it shall be a non-tilting type and shall be completely suspended from a springless dial scale. Load cells with digital readouts may be used if approved by the Engineer. The weigh bucket, its discharge valve or valves and spray bar shall be adequately heated and shall have a capacity of at least 15 percent in excess of the mass (weight) of bituminous material required in any batch. Adequately heated quick-acting, non-drip, valves shall be used in charging the bucket.

If a metering device is used, it shall be of an approved design and have a capacity of at least 15 percent in excess of the quantity of bituminous material used in a batch. The controls shall be constructed so that they may be locked at any dial setting and will automatically reset to that reading after the addition of bituminous material to the mix. The dial shall be in full view of the mixer operator. The flow of bituminous material shall be automatically controlled so that it will begin when the dry mixing period is over. The section of the bituminous line between the charging valve and the spray bar shall be provided with a valve and outlet for checking the meter.

Either the weigh bucket or the meter device shall discharge all the bituminous material required for one batch in not more than 15 seconds after the flow has started. The size and spacing of the spray bar openings shall provide a uniform application of bituminous material the full length of the mixer.

(4) Accuracy of Scales. The scales shall meet the requirements of The Weights and Measures Act of the State of Illinois. The scales shall be calibrated at the beginning of each construction season and as often as the Engineer may deem necessary to assure their continued accuracy. The scales shall be inspected frequently for sensitivity, sluggishness or damage. They shall be checked for accuracy at intervals of not more than one week by obtaining the net mass (weight), on truck scales, of a truck load of bituminous mixture.

(5) Pugmill Mixer. The batch mixer shall have a rating plate attached showing the manufacturer's rated capacity, and shall be an approved type capable of producing a uniform mixture within the job tolerances. If not enclosed, the mixer box shall be equipped with a dust hood to prevent loss of dust. The clearance of the blades from all fixed and moving parts shall not exceed 20 mm (3/4 inch).

The capacity of the pugmill mixer will be determined by the Engineer based on 115 percent of the calculated net volume of the mixer below the center of the mixer shafts and 1600 kg/m³ (100 lbs. per cu. ft.) material. If the mixer will not operate efficiently at the approved capacity, or if its production does not coordinate with other plant units, the right is reserved to reduce the size of the batch until the desired efficiency is obtained. The Engineer's decision as to the permissible capacity of the pugmill mixer will be final.

The mixer shall be heated by an approved method and shall have a capacity of not less than 905 kg (2000 lbs.) for any composition required under these Specifications. The amount of material which the Contractor will be permitted to mix per batch shall be determined by the Engineer. The mixer shall be of the twin-shaft type. Drip pans shall be used under the mixer where necessary to prevent moisture from dropping into truck loads of freshly prepared bituminous mixture. All pipe fittings shall be tight. The mixer platform shall be sufficiently rigid and of ample size to provide safe and convenient access to the mixer and other equipment.

(6) Time Lock. The mixer shall be equipped with an accurate time lock to control the operations of a complete mixing cycle. It shall lock the weigh box gate after the charging of the mixer until the closing of the mixer gate at the completion of the cycle. It shall lock the bituminous material bucket throughout the dry mixing period and shall lock the mixer gate throughout the dry and wet mixing periods. The dry mixing period is defined as the interval of time between the opening of the weigh box gate and the start of introduction of bituminous material. The wet mixing period is the interval of time between the start of introduction of bituminous material and the opening of the mixer gate.

The control of the timing shall be flexible and capable of being set at intervals of 5 seconds or less throughout a total cycle. The setting of time intervals shall be performed in the presence and at the direction of the Engineer.

- (7) Batch Counter. An approved mechanical batch and/or tonnage counter shall be installed as part of the time lock device. It shall register only upon the actuation of the asphalt weigh bucket or valve release. It shall not register any dry batches or any material released during the operation of pulling the bins.
- (c) Special Requirements for Continuous Mixing Plants.
  - Gradation Control Unit. The plant shall include means for accurately proportioning each size of aggregate and mineral filler.

The plant shall have a feeder mounted under each compartment bin. Each compartment bin shall have an accurately controlled individual gate to form an orifice for volumetrically measuring the material drawn from each compartment. The feeding orifice shall be rectangular with one dimension adjustable by positive mechanical means provided with a lock.

Bins shall be equipped with adequate telltale devices to indicate the position of the aggregates in the bins at the lower quarter points.

A cutoff system shall be provided which shall automatically stop the mixing operations when any bin becomes empty or when the bitumen reaches a level in the tank where the specified quantity of bitumen is not delivered to the pugmill.

Indicators graduated in 2.5 mm (0.10 inch) divisions and marked in millimeters (inches) shall be provided on each gate to show the gate opening.

- (2) Weight Calibration of Aggregate Feed. The plant shall include a means for calibration of gate openings by weighing test samples. Provision shall be made so that materials fed out of individual orifices may be bypassed to individual test boxes. The plant shall be equipped to conveniently handle individual test samples weighing not less than 90 kg (200 lbs.). Accurate scales shall be provided by the Contractor to weigh such test samples.
- (3) Synchronization of Aggregate Feed and Bituminous Material Feed. Satisfactory means shall be provided to afford positive interlocking control between the flow of aggregate from the bins and the flow of bituminous material from the meter or other proportioning device.

This control shall be accomplished by interlocking mechanical means or by any other positive method satisfactory to the Engineer.

A revolution counter graduated in 0.01 revolution shall be conveniently located on the plant. A convenient means shall be provided for checking, by mass (weight), the flow of the bitumen.

Mixer. The plant shall include a continuous mixer of an approved type, adequately heated and capable of producing a uniform mixture within the job-mix tolerances. It shall be equipped with a discharge hopper with dump gates which will permit rapid and complete discharge of the mixture. The paddles shall be adjustable for angular position on the shafts and reversible to retard the flow of the mix. The spray bar of the mixer shall be equipped with a pressure gauge. An adjustable baffle or dam which can be locked or bolted in position shall be placed at the discharge end of the pugmill. The mixer shall have a nominal capacity, as determined by the Engineer, of not less than 55 metric tons (60 tons) per hour and shall have a manufacturer's plate giving the net volumetric contents of the mixer at the several heights inscribed on a permanent gauge. Charts shall be provided showing the rate of feed of aggregate per minute for the aggregate being used. Unless otherwise required, the mixing time shall be determined by the weight method using the following formula. The mass (weights) will be determined for the job by tests made by the Engineer.

Mixing time Pugmill dead capacity, kg (lbs.)
in seconds = Pugmill output, kg (lbs.) /sec.

The pugmill shall be equipped with a discharge hopper having a minimum capacity of 1 metric ton (1 ton).

- (5) Platform Scale for Weighing Bituminous Mixtures. The bituminous mixture shall be weighed on approved scales furnished by the Contractor meeting the requirements of The Weights and Measures Act of the State of Illinois. Each time the scale is moved, the accuracy shall be retested and certified.
- (d) Special Requirements for Drier Drum Plants for Class I Mixes.
  - (1) General. General requirements shall meet the requirements of Article 1102.01(a) except (5),(6),(7),(8),(9),(11) and (12) will not apply, and a hot-mix surge bin meeting the requirements of (10) shall be utilized.
  - (2) Asphalt Storage. Tanks for the storage of bituminous material shall be equipped to heat and hold the material at the required temperatures. The heating shall be accomplished by steam coils, hot oil coils, electricity, or other approved means. All asphalt lines and fittings shall be steam, electric, or hot oil jacketed. Provisions shall be made for sampling the asphalt from the line leading to the asphalt pump. A sensing device for a recording pyrometer or thermometer shall be suitably located in the asphalt line leading to the asphalt pump.
  - (3) Aggregate Bins and Feeders. The plant shall be provided with a minimum of 4 aggregate bins and feeders. The bins shall be designed to prevent overflow of material from one bin to another. Each bin shall be provided with a variable speed belt or apron feeder with adjustable gates which can be locked. Each bin shall have a cutoff system that shall automatically stop the feeding operation when any bin becomes empty. The combined materials shall pass over a vibrating scalper that will remove all material and aggregate greater than the nominal top size gradation permitted by the specification for the mixture being produced, or as set by the Engineer, prior to the aggregates being placed on the weigh belt. The scalper shall be independent of other proportioning or weighing equipment.
  - (4) Aggregate Weighing Equipment. The combined aggregates shall be weighed on a continuous belt weighing device meeting the requirements of The National Bureau of Standards, Handbook #44. The weigh belt shall be self-aligning with a gravity belt takeup and rigid wind guards at the weighing section. Sun screens may be required by the Engineer at the weighing section. Means shall be provided to divert the aggregate into a truck, after passing over the weigh belt scale. In order to obtain samples, the Contractor may choose to either stop the weigh belt when requested by the Engineer, or provide an automatic sampling device meeting the approval of the Engineer.
  - (5) Mineral Filler System. Mineral filler shall be proportioned to the drier drum by a variable speed vane feeder and storage system or other systems approved by the Engineer. Means must be provided to divert material from the proportioning unit for purposes of calibration. The feeder shall be provided with an automatic cutoff system in the event

the feeder is blocked or is devoid of material.

- (6) Asphalt System. The asphalt system shall consist of a temperature compensating meter and pump. Other asphalt systems may be used if approved by the Engineer. The pump and meter shall be installed as close to the asphalt storage tank(s) as possible using rigid pipe with a minimum of piping length and bends. The diameter of the pipe leading to the meter from the tank and pump shall be approximately the same size as the meter input diameter. Means shall be provided to automatically stop the plant in the event asphalt ceases to flow through the meter.
- (7) Drier Drum Mixer. The drier drum mixer shall be a revolving cylindrical drum capable of mixing and heating the aggregate and asphalt to produce a completely coated homogeneous bituminous mixture. The burner shall be equipped with automatic burner controls and a recording pyrometer or thermometer that records the temperature of the mix at the drum discharge.
- (8) Dust Collector. If a dust collector is required to meet State and local requirements, the collected dust shall be returned to the dryer at a uniform rate at a point where the asphalt is added to the drier. Other dust collection systems will be permitted if approved by the Engineer.
- (9) Proportioning Control Systems.
  - a. Aggregate Feed Control. Each aggregate feeder shall have an adjustable feed control, which can be locked, with a master control that will automatically increase or decrease the production rate of each feeder proportionately when the total rate of production is changed. The RPM, TPH, etc. of each feeder shall be measured at the tail shaft of the feeder.
  - b. Aggregate Weighing. The main proportioning weigh belt shall be electronically interfaced with the asphalt and mineral filler system to proportion the required amount of each material simultaneously to the drum. The aggregate weighing system shall have an accuracy of ±0.5 percent of the actual material weighed by the belt. The weighing system shall also have a high-low adjustable tolerance indicator that will signal the operator audibly when the actual production rate differs from the preset rate by more than 3.0 percent.
  - c. Mineral Filler Control. Mineral filler shall be added to the drum by a variable speed proportioning system interfaced with the aggregate weigh belt that will indicate total dry aggregate combined (aggregates + mineral filler) mass (weight) to the asphalt proportioning system. The mineral filler system shall have an accuracy of 0.3 percent of the total mix mass (weight). The filler shall be added in the drum at the same point the asphalt is added in order that no filler is lost as fugitive dust. Other systems will be permitted if approved by the Engineer.
  - d. Asphalt Control. The required quantity of asphalt shall be proportioned to the drum via a temperature compensating meter that will correct the quantity of asphalt to 15 °C (60 °F.), or a system approved by the Engineer. This system shall be electronically interfaced with the combined dry aggregates and

- mineral filler. The meter shall have an accuracy of 0.1 percent of the total mass (weight) of the bituminous mixture.
- e. Aggregate Moisture Compensator. The moisture compensation device shall be capable of electronically converting the wet aggregate mass (weight) to dry aggregate mass (weight). The compensator shall be manually set. Other systems will be permitted if approved by the Engineer.
- (10) Control Console. The following items shall be part of the operator's control console:
  - a. Aggregate Feed Controls. The variable speed controls, both total and proportional for each feeder and combined aggregates, shall be indexed in units with a minimum unit of 0.1. The rate in RPM or TPH, etc. shall be displayed by a digital readout for each feeder with a minimum unit of 0.1 RPM or 1 TPH, etc.
  - b. Aggregate Mass (Weight) Indicator. The accumulated wet mass (weight) of material in metric tons (tons) that passes over the weigh belt shall be available at the control console with a minimum unit of 0.1 metric ton (0.1 ton). The dry mass (weight) of material, in TPH, passing over the weigh belt shall be displayed by digital readouts with a minimum unit of 1 TPH.
  - c. Mineral Filler Control. Mineral filler shall be controlled by a variable speed control with a minimum unit of 0.1 and shall be displayed in RPM, or TPH, etc. with a minimum unit of 0.1 RPM or 0.1 TPH, etc.
  - d. Asphalt Control. The asphalt control shall be capable of presetting the actual asphalt content directly as a percent of the total mass (weight) of mixture with a minimum unit of 0.1 percent. The asphalt rate shall be displayed to a minimum unit of 0.1. A control shall be provided to set the specific gravity or mass (weight) per liter (gallon) of the asphalt. The temperature of the asphalt shall be recorded by a recording pyrometer or thermometer at the console.
  - e. Aggregate Moisture Compensator. The aggregate moisture compensator shall be part of the operator's console and shall have a minimum unit of 0.1 percent. The control shall be lockable if the moisture setting is not printed as part of the recordation.
  - f. Mix Temperature. The temperature of the mixture shall be recorded in degrees Celsius (Fahrenheit) by a recording pyrometer or thermometer at the console.
- (11) Recordation of Proportions. The plant shall be equipped with a digital printer that will automatically print the following data at 6 minute intervals during production time and on demand. All readings shall show the date, month and year, and time to the nearest minute for each print.
  - a. Accumulated dry aggregate in metric tons (tons) to the nearest 0.1 metric ton (0.1 ton).
  - b. Accumulated mineral filler in revolutions, metric tons (tons), etc.,

to the nearest 0.1 unit.

- Accumulated asphalt in liters (gallons), metric tons (tons), etc., to the nearest 0.1 unit.
- d. Aggregate Moisture Compensator in percent as set at the panel. (Required when accumulated dry aggregate is printed in Wet Aggregate Mass (Weight)).

Another system approved by the Engineer, such as a fully computerized system, that will provide the control and documentation of the above equipment, will be permitted.

- (e) Special Requirements for Drier Drum Plants for Other Than Class I Mixes.
  - (1) General. The general requirements shall be in accordance with Article 1102.01(d) except as follows:

The plant must be calibrated and approved prior to the start of production. Adequate means must be provided to divert the individual or combined aggregates into a truck after the aggregates pass over the weigh belt or other proportioning device and prior to being deposited into the drier. The asphalt pump shall be calibrated at the same time the weigh belt is being calibrated by diverting the asphalt into a tank. The plant must be provided with hand rails, safety guard(s) and other protective devices. Clear and unobstructed passage shall be maintained at all times in and around the truck loading area. Accessibility to the top of truck bodies shall be provided, by a platform or other suitable device constructed near the surge bin, to enable the Engineer to obtain sample s and mixture temperature data.

- (2) Article 1102.01(d)(4),(9) and (10) shall not apply.
- (3) Aggregate Feeders. The plant shall be provided with accurate mechanical means for uniformly feeding each aggregate in its proper proportion into the drier drum mixer so that uniform production and uniform temperature will be obtained. One bin and feeder will be required for each aggregate proportioned into the mix. Each bin shall have a low level warning device that will sound a warning when the aggregate in any bin is less than 300 mm (12 inches) above the top of the discharge gate. A scalper or other device that will remove large clay lumps or debris will be required prior to the aggregates being placed on the weigh belt.
- (4) Mineral Filler System. A mineral filler system meeting the approval of the Engineer will be required when the final mix does not contain the required amount of minus 75 μm (No. 200) sieve material.
- (5) Proportioning Control. The combined aggregates shall pass over a weigh belt or belt scale that is electronically interlocked with the asphalt pump and will proportion the proper amount of asphalt at the point where the aggregate and asphalt are simultaneously being added to the drier drum mixer. The weigh belt shall have an electronic readout or display at the operator's station that shows the total metric tons (tons) per hour passing over the belt. The asphalt pump shall be a positive displacement type pump with a circulating asphalt system that calibrates within 0.5 percent of the theoretical asphalt at any given production rating. The asphalt pump shall be equipped with a

revolution counter or meter and a pyrometer or thermometer probe to record the asphalt temperature with the data being transmitted to the operator's station.

- (6) Surge Bins. The surge bin shall be designed and operated to prevent segregation and loss of temperature of the mix. The bins shall be insulated and/or heated and of an enclosed weatherproof type when used in temperatures below 5 °C (40 °F.). The conveying system used to transport the mix from the drier drum mixer to the bin shall also be enclosed when used in temperatures below 5 °C (40 °F.).
- (7) Control Devices. The following items shall be part of the operator's control console:
  - a. Cold aggregate feed controls which indicate the relative output of each individual feeder and the collecting feeder and which have the capability of both individual and proportional control of the aggregates.
  - Drier burner controls which automatically control the temperature of the mix and record the mix temperature at the drier discharge.
  - Weigh belt readout which indicates the amount of material crossing the belt.
  - d. Asphalt pump revolution counter or meter readout which indicates the asphalt being proportioned into the mix and a recording pyrometer or thermometer which records the asphalt temperature prior to entering the pump.
  - Proportioning control dials for setting the asphalt content and making the moisture adjustment that are capable of being key locked.

1102.02 Traveling Plant. The traveling plant shall meet the approval of the Engineer. It shall be self-propelled and capable of maintaining a uniform rate of travel while mixing. It shall be mounted on pneumatic-tired wheels or smooth tread crawler tracks of such width that the base will not be rutted or damaged when the plant is loaded to capacity. The plant shall have a capacity of not less than 230 m<sup>3</sup> (300 cu. yds.) of mixed material per 8 hour day, and shall be so designed and constructed that it will pick up all of the aggregate cleanly from the windrow without damaging the base. It shall measure accurately and mix thoroughly the bituminous material and aggregate, and deposit the mixture in a uniform windrow or in a manner satisfactory to the Engineer. The plant shall be equipped with insulated storage tanks containing heaters, and the storage tanks shall have a capacity sufficient to ensure continuous operation. Positive acting devices for accurately adjusting and controlling the feed of the aggregate and bituminous material shall be placed conveniently within the operator's reach. The plant shall be equipped with the necessary instruments for determining the quantity of bituminous material going into the mix during any given time, and a thermometer for indicating the temperature of the bituminous material at the time of mixing.

1102.03 Spreading and Finishing Machine. Bituminous pavers shall be self-contained, power-propelled units equipped with augers, activated screed or a strike off assembly and be capable of being heated. The augers, activated screed or strike off assembly shall be adjustable either automatically or by adding additional sections so the paver will lay, compact or strike off the bituminous plant mix material

to the full width being placed. All width extensions required to place material on the traffic lanes shall have the same placement features and equipment functions as provided on the main body of the paver. Pavers with extendible type screeds shall have a minimum 3 m (10-ft.) basic screed except on projects with 6300 m² (7500 sq. yds.) or less of bituminous concrete. For these smaller projects, a minimum 2.4 m (8 ft.) basic screed will be permitted. Augers shall be extended as additional sections of screed are bolted on or automatically adjustable screeds are extended. The augers need not be extended when the screed extensions on each side of the machine are 300 mm (1 ft.) or less if the finished surface of the mat is uniform. Pavers used for shoulders and similar construction shall be capable of spreading and finishing courses of bituminous plant mix material in widths shown on the plans. The use of any machine obsolete in design or in poor mechanical condition will not be permitted.

When placing bituminous concrete binder and surface course Class I, the spreading and finishing machine shall be equipped with an automatic electronic grade control device. The device shall be effective in leveling depressions in the surface of the existing pavement, the leveling course and the binder course.

The automatic electronic grade control device shall be capable of controlling the elevation of the screed relative to either a preset grade control stringline or a grade reference device traveling on the adjacent pavement surface. The traveling grade reference device shall be not less than 9 m (30 ft.) in length.

The paver shall be equipped with a receiving hopper having sufficient capacity for a uniform spreading operation. The hopper shall be equipped with a distribution system to place the mixture uniformly in front of the screed.

The screed or strike off assembly shall effectively produce a finished surface of the required evenness and texture without tearing, shoving or gouging the mixture.

When laying mixture, the paver shall be capable of being operated at forward speeds consistent with satisfactory laying of the mixture.

**1102.04 Spreaders.** The aggregate spreader used in placing aggregates in layers of 25 to 300 mm (1 to 12 inches) shall be of a design approved by the Engineer. The aggregate spreader shall contain a strike off plate capable of being adjusted so as to place the material in uniform layers from 25 to 300 mm (1 to 12 inches) in depth. It shall be equipped with two end gates or cut off plates, so that the aggregates may be spread in widths varying up to lane width.

The aggregate spreader used in spreading aggregate for surface treatments, keystone coat and seal coat shall be of a mechanical type approved by the Engineer. It shall distribute the aggregate uniformly, and shall be capable of being adjusted so that the spreading rate of the aggregate will not vary more than 1 kg/m<sup>2</sup> (2 lbs. per sq. yd.).

- **1102.05 Pressure Distributor.** The pressure distributor used for applying liquid bituminous materials shall be a self-propelled motor vehicle and shall meet the requirements given hereinafter:
  - (a) Truck. The truck shall be capable of operating smoothly at speeds as low as 1.3 km/h (0.8 mph) when used on heavy penetration construction, and at normal road speeds when used for transporting bituminous materials. In order to develop these speeds satisfactorily, the truck shall have at least 4 speeds forward.
  - (b) Tank. The tank on the distributor shall have a capacity of not less than

2250 L (600 gals.). Approval shall be obtained from the Engineer for the use of a distributor having a capacity greater than 9450 L (2500 gals.). The tank shall be covered with at least 25 mm (1 inch) of approved insulation. It shall be equipped with a removable manhole cover, an overflow pipe and a suitable strainer located at the intake or outlet to the pump to prevent the passage of any material which might clog the nozzles. A dial gauge plainly visible to the spray bar operator shall be conveniently placed to indicate the contents of the tank at various levels.

- (c) Heating System. The distributor shall be equipped with an approved heating system to heat the bituminous material. The heating system shall consist of heat flues having sufficient radiation to ensure the rapid circulation of hot gases of combustion from one or more efficient smokeless burners of the torch type, a circulating device to ensure uniform heating of the material, and a suitable fuel supply tank.
- (d) Pump. The distributor pump shall be of the rotary positive pressure type of sufficient size and discharge capacity to apply uniformly the specified amount of bituminous material per square meter (square yard) in widths up to 7.2 m (24 ft.). It shall be driven in the most direct method obtainable by a gasoline motor other than the vehicle propelling motor or by other methods approved by the Engineer. The pump motor shall have sufficient power to operate the distributor pump at the required volume and pressure. If the motor pump is equipped with a transmission, it shall have a governor. Suitable housing or heating jackets shall be provided to enclose the distributor pump and piping in order to retain the heat and to ensure a constant, even flow of the material.
- (e) Spray Bars. Spray bars of various lengths shall be used to spray the bituminous material over widths varying from 1.2 to 7.2 m (4 to 24 ft.). The spray bars shall be arranged so that they may be swung from side to side over a distance of not less than 225 mm (9 inches) to match joints and to clear obstructions. They shall be equipped with spray nozzles of such design and size of orifice as to ensure uniform distribution of the bituminous material in the specified quantities. Means shall be provided to stop the flow of bituminous material quickly and to prevent it from dripping when the flow is shut off.

Means shall be provided for obtaining samples of the material from the tank or from the piping leading from the tank to the spray bars.

A hand spray bar and nozzle having a suitable length of flexible hose with packed couplings shall be provided for applying material at intersections, shoulders and similar locations.

- (f) Thermometer. A mercury thermometer having the stem extending into the material or into an approved well shall be placed in a suitable position in the tank to give a true average temperature of the contents of the tank.
- (g) Operator's Platform. A substantial platform for the operator shall be provided at the rear of the distributor. It shall be so located that it will provide a clear view of the operation of the spray bars.
- (h) Tachometer or Synchronizer. A tachometer shall be attached to the truck in such a manner as to be visible to the truck operator and to enable him/her to maintain the constant speed necessary for the correct application of the specified quantity of bitumen. Suitable charts shall be furnished

showing the truck speeds necessary to obtain the required results.

- When a synchronizer is used, the tachometer may be omitted. The synchronizer shall deliver a specified quantity of bituminous material on the road surface regardless of the speed of the truck.
- (i) Calibration. The distributor will be calibrated by the Engineer before the work is started and the Contractor shall furnish all equipment, tools, materials and assistance necessary to make the calibration.
- 1102.06 Road Mixer. The bituminous paving mixer shall be mounted on pneumatic-tired wheels and shall consist of at least 6 delivery mold boards, 2 distribution blades and a strike off blade. All delivery mold boards shall be set at 45 or 135 degree angles to the line of travel. At least 4 mold boards shall be set for inward delivery of the mixture and at least 2 shall be set for outward delivery. The height of the mold boards shall be at least 530 mm (21 inches). They shall be curved and shall be replaceable. The 2 distribution blades shall be curved and their height shall be at least 530 mm (21 inches). They shall be placed between the delivery mold boards and the strike off blade. The strike off blade shall be set at a right angle to the line of travel. It shall be flat, the height shall be not less than 530 mm (21 inches), the length shall be 3 to 3.6 m (10 to 12 ft.), and it shall be equipped with adjustable end gates capable of placing the mixture upon the base in layers 2.1 to 3 m (7 to 10 ft.) wide, and to the desired cross section and crown.
- 1102.07 Heating Equipment. The heating equipment shall have sufficient capacity to heat the bituminous material properly by circulating steam or hot oil through coils of the tank car or storage tank, or by any other method approved in writing by the Engineer. Tank cars which have defective coils or which are without coils will be rejected on the work by the Engineer unless some satisfactory auxiliary means can be provided by the Contractor to heat the bituminous material without the introduction of moisture. The use of any equipment to agitate the bituminous material while it is being heated will be prohibited if, in the opinion of the Engineer, it injures, or in any way changes the characteristics of the bituminous material. The use of a tank car connection or any other equipment by means of which free steam or hot oil can be introduced directly into the bituminous material will not be permitted.
- **1102.08 Drag.** The drag shall be a broom drag of a design approved by the Engineer. It shall be not less than 5 m (16 ft.) in length and not less than 1.8 m (6 ft.) in width. It shall have at least 2 transverse and 2 diagonal rows of brooms. Other types of drags may be used upon approval of the Engineer.
- **1102.09 Windrow Evener.** The windrow evener shall be of a type approved by the Engineer. It shall be so constructed that a uniform windrow can be obtained. There shall be an adjustable end gate so that the cross section of the windrow can be varied.
- **1102.10 Graders.** The road grader shall be a self-propelled, pneumatic-tired grader having an end plate attached to the blade. The design of the grader shall meet the approval of the Engineer. It shall be constructed rigidly and be free from worn parts so that no jumping of the blade occurs. It shall be equipped with an oil mix type blade 3.6 to 4.3 m (12 to 14 ft.) long, not less than 450 mm (18 inches) high, and shall have sufficient mass (weight) to prevent slipping of the wheels. The blade shall be sufficiently curved so that any coated aggregate working before it shall be cascaded in front of it. The rubber tires shall be of such width that they will not cut materially into the surface.

1102.11 Micro-Surfacing Mixing Machine. The mixing machine shall be a self-propelled continuous flow mixing unit equipped with a chain dragged conveyor belt aggregate delivery system and an interconnected positive displacement gear pump to accurately proportion and deliver ingredients to a revolving multi-blade mixer and discharge the thoroughly-mixed product on a continuous flow basis. twin-shafted multi-blade pugmill shall be a minimum of 1270 mm (50 inches) long. The emulsion shall be introduced above the third point of the mixer to ensure proper pre-mixing of the aggregate, cement, additive, and water when the modified emulsified asphalt is added. Blade size and side clearances shall meet the equipment manufacturer's recommendations. The machine shall have sufficient storage capacity for aggregate, emulsified asphalt, mineral filler and water to maintain an adequate supply to the proportioning control. The machine shall be equipped with self-loading devices which provide for the loading of all materials while continuing to lay micro-surfacing, thereby eliminating unnecessary construction joints. The mixer shall be equipped with a remote forward speed control at the back mixing platform so the back operator can control forward speed and level of mixture in the paver box or rutbox.

Individual volume or weight controls for proportioning each material to be added to the mix shall be provided. Each material control device shall be calibrated and properly marked. They shall be accessible for ready calibration and so placed that the Engineer may determine the amount of each material used at any time.

The aggregate feed to the mixer shall be equipped with a revolution counter or similar device so that the amount of aggregate used may be determined at any time.

The emulsion pump shall be the positive displacement type and shall be equipped with a revolution counter or similar device so that the amount of emulsion used may be determined at any time.

The mixing machine shall be equipped with a water pressure system and nozzle type spray bar to provide a water spray immediately ahead of and outside the spreader box.

The mixing machine shall be equipped with a fines feeder that provides an accurate metering device or method to introduce a predetermined proportion of miner filler into the mixer at the same time and location that the aggregate is fed. The fines feeder shall be used whenever mineral filler is a part of the aggregate blend.

1102.12 Micro-Surfacing Spreader. The micro-surfacing spreader shall be a mechanical type squeegee box equipped with paddles mounted on adjustable shaft to continually agitate and distribute the mix throughout the box. The spreader shall be attached to the mixing machine and shall provide sufficient turbulence to prevent the mix from setting in the box or causing excessive side build-up or lumps. The squeegee box shall be equipped with flexible seals attached to the front and rear, and in contact with the pavement surface, to prevent loss of mixture from the box. A specially designed rutbox with a steel strike off capable of placing a crown in the mix shall be provided for filling ruts. The equipment shall be capable of filling cracks and minor surface irregularities and achieving a uniform surface without causing skips, lumps, or tears in the finished surface.

### SECTION 1103. PORTLAND CEMENT CONCRETE EQUIPMENT

### 1103.01 Concrete Mixers.

(a) Stationary Mixer. The mixer shall be of the batch type of approved design.

Except as further provided, the mixer used for paving shall have a rated capacity of not less than  $0.8~\text{m}^3$  (28 cu. ft.) of mixed concrete. The mixer shall be capable of discharging the concrete directly into truck agitators or nonagitating trucks for conveyance to the job. If more than one batch is required for charging a truck, the time of haul shall be reckoned from the start of mixing of the first batch. The mixer for structures and incidental construction shall have a rated capacity of not less than  $0.25~\text{m}^3$  (10 cu. ft.) for structures involving the placement of  $23~\text{m}^3$  (30 cu. yds.) or more, and not less than  $0.2~\text{m}^3$  (7 cu. ft.) of mixed concrete for placements less than  $23~\text{m}^3$  (30 cu. yds.).

The mixer shall be equipped with a batch meter for counting the batches, and an approved timing device which will automatically lock the discharge lever during the full time of mixing and release it at the end of the mixing period. The timing device shall be equipped with a bell, adjusted to ring each time the lock is released. If the timing device becomes broken or out of order, the Contractor will be permitted to operate while it is being repaired, provided the Contractor furnishes an approved timepiece equipped with minute and second hands, and provided further that each batch is mixed 1 1/2 minutes. If the timing device is not replaced in good working order within 72 hours, further use of the mixer will be prohibited until repairs are made.

When measuring water by volume, the mixer shall be equipped with a water measuring device which shall be capable of measuring and discharging the specified amount of water within a limit of accuracy of 1 percent, provided a limit of accuracy closer than 1 L (1 qt.) will not be required, and shall be so arranged that the accuracy of measurement will not be affected by variations in pressure in the water supply line. A water glass placed vertically on the water tank shall not be used as a water measuring device. The water measuring equipment shall include an auxiliary tank of approved design from which the water measuring tank shall be filled. The volume of the auxiliary tank shall be not less than the volume of the measuring tank. The equipment shall be so arranged that the water pressure in the measuring tank cannot exceed that due to the difference in elevation between the 2 tanks. The measuring tank shall be equipped with an outside tap and valve to provide for checking the graduation on the indicator, unless other means are provided for readily and accurately determining the amount of water discharged. Means shall be provided to automatically stop the flow of water from the measuring tank when the desired quantity has been delivered. If the specified amount of water can be provided without the auxiliary tank, the auxiliary tank will not be required.

When measuring water by mass (weight), the requirement for the scale shall be as specified in Article 1103.02(c), the accuracy of measuring shall be as specified above, and means shall be provided for automatically stopping the flow of water into the weighing container at the moment the correct amount has been delivered. The Department may approve the use of a water meter for measuring mixing water provided it rigidly meets the requirements for automatic stop of the flow of water and accuracy of measurement.

Pickup and throw-over blades in the drum of the mixer which are worn down 20 mm (3/4 inch) or more in depth shall be replaced with new blades.

(b) Truck Mixer. Truck mixers shall be either the type having a watertight revolving drum, suitably mounted and fitted with adequate blades attached to the drum, or the type having an open-top, watertight, trough-like container, suitably mounted and fitted with adequate blades revolving about an axis parallel to the axis of the trough. Truck mixers shall be capable of combining aggregates, cement and water into a uniform mixture, and of discharging the mixture without segregation. Each truck mixer shall have attached to it a metal plate on which is stated its capacity in terms of volume of mixed concrete for the various uses to which the equipment is applicable and the Manufacturer's recommended mixing speed.

Truck mixers, except when used exclusively for agitating premixed concrete, shall be provided with a batch meter and locking device capable of preventing the discharge of the concrete before the required number of revolutions has been obtained, or with an approved revolution counter, suitably mounted, to provide a means of verifying the amount of mixing obtained.

The water measuring device shall be capable of measuring and discharging the specified amount of water within a limit of accuracy of 1 percent. If the water is added during transit, the measuring device may be mounted upon the truck mixer, and an outside tap or valve shall be provided for checking the graduations on the indicator, unless other means are provided for readily and accurately determining the amount of mixing water discharged. Provisions shall be made to automatically stop the flow of water when the desired amount has been delivered. If not mounted on the truck mixer, the water measuring device shall be located at the site selected for adding the water, and shall conform to the requirements of Article 1103.01(a). A water glass placed vertically on the water tank shall not be used as a water measuring device except for final slump adjustment at the job site.

The equipment for weighing and batching the materials for truck mixing shall comply with Article 1103.02.

- (c) Truck Agitator. Truck agitators shall be either the type having a watertight revolving drum, suitably mounted and fitted with adequate blades attached to the drum, or the type having an open-top, watertight, trough-like container, suitably mounted and fitted with adequate blades revolving about an axis parallel to the axis of the trough. The truck agitator, when fully loaded, shall be capable of maintaining the mixed concrete in a thoroughly mixed and uniform mass, and of discharging the concrete without segregation. The agitator shall transport and discharge the concrete without leakage of any of the ingredients. Each truck agitator shall have attached to it a metal plate on which is stated its capacity in terms of volume of mixed concrete for the various uses to which the equipment is applicable.
- (d) Nonagitator Trucks. Nonagitating trucks shall have special bodies. The special bodies shall be smooth, watertight, metal containers and shall be capable of discharging the concrete at a satisfactorily controlled rate and without segregation. The truck bed shall be constructed so that the concrete will be discharged from the bottom of the container. A watertight cover shall be used to protect the concrete being hauled when it is raining.

**1103.02 Batching and Weighing Equipment.** The plant shall be approved before production begins. The bins, weighing hoppers and scales shall be arranged to the satisfaction of the Engineer so that the weigh beam "telltale" dial or the dial

scale is in full view of the operator as he/she controls the gates, valves or belts that feed the material into the weighing hopper. The plant shall be equipped with a room of approximately 20 m² (200 sq. ft.) for performing the necessary tests for control of the mixture. The room shall be provided with sufficient heat, natural and artificial light, air conditioning, and be equipped with a desk, chair, drafting stool, work bench 0.9 x 3 x 0.9 m (3 x 10 x 3') high with drawers and cabinets below, service sink and water supply and 110 volt outlets. First aid equipment, telephone and fire extinguisher having a minimum Underwriters Laboratory rating of 2A10BC and sanitary facilities shall be available. When approved by the Engineer, a room with sufficient space for performing the necessary tests for control of the mixture, either in a building occupied by the ready-mixed concrete operator or in a separate building satisfactory to the Engineer, may be substituted for the aforementioned facility. The equipment used for batching and weighing the materials shall comply with the following requirements:

(a) Bins. Bins having sufficient capacity for adequate supply of materials to the weighing hoppers shall be provided. They shall be supported by rigid frame work on a safe foundation. Portable type bins shall be fully loaded and permitted to stand for at least 12 hours before operations start. Bins shall have adequate separate compartments for each required size of fine and coarse aggregate and for bulk cement when used. Except for permanent ready-mix plants, the top of the fine aggregate compartment shall be equipped with a tilted screening device which shall reject all material coarser than 25 mm (1 inch) and thru which all fine aggregate must pass upon entering that compartment. Each compartment shall be designed to discharge material efficiently and freely into the measuring hopper.

Means of control shall be provided so that when the quantity to be obtained is being approached, the flow of the material can be gradually retarded and completely shut off, without leakage, at the moment the desired amount has been discharged.

The use of bins for batching materials for job mixed concrete for structures and incidental construction shall not be mandatory when mixers designated as "16 S" and smaller are used.

(b) Weighing Hoppers. The hoppers shall be completely suspended from the scales and shall otherwise hang free and, except as further provided, shall have sufficient capacity to contain the material or materials to be weighed for one batch of concrete without shoveling and without jiggling the hopper to keep bin gates and chute openings free of material during the weighing. Cement shall be weighed in a hopper entirely free and independent of the hopper or hoppers used for weighing the aggregate. When manually batching other cementitious materials shall also be weighed in a separate hopper. Other cementitious material may be weighed into the cement weigh hopper for automatic or semi-automatic batching.

Batching equipment, insufficient in capacity for weighing the materials required for a full batch, will be permitted in batching materials for job mixed concrete for structures and incidental construction when mixers designated as "16 S" and smaller are used.

Batching equipment, insufficient in capacity to weigh the materials required for a full batch, will be permitted in the case of large capacity central mixers and truck mixers provided that the capacity of the hopper or hoppers is sufficient to weigh all the materials for at least 0.75 m<sup>3</sup> (1 cu. yd.) of

concrete for any mixer of rated capacity of 0.75 m<sup>3</sup> (1 cu. yd.) or larger. The disproportionality between batching equipment and mixer shall not be so great that more than 3 weighings of each material will be required for charging the mixer.

All hoppers except cement shall have a port or other opening for removal of overload of any one of the materials unless sufficient clearance for this purpose exists between the bottom of the bin gate and the top of the hopper. The top of the cement hopper shall be closed to prevent the escape of cement while it is being weighed. Hoppers shall be constructed in a manner that will eliminate the accumulation of tare material and leakage through the discharge gates during weighing. They shall be capable of discharging the material efficiently and completely into the batch trucks or mixer without the necessity of beating or jiggling. If any hopper, in the opinion of the Engineer, does not discharge the material satisfactorily, it shall be provided with a vibrator of sufficient frequency and power to assure complete discharge. All weighing hoppers shall be enclosed or otherwise protected against wind.

When bins are not required, the materials shall be weighed in approved containers. End loaders shall not be used for loading the weighing hopper.

(c) Scales. The scales may be of either the horizontal beam or the springless dial type, shall be designed as an integral unit of the batching plant, and shall be of rugged construction to withstand the usage for which they are intended. Load cells with digital readouts may be used if approved by the Engineer.

Beam type scales shall have as many beams and of such capacities as will permit the required mass (weight) of each size or kind of aggregate to be set off on a single beam except that when one size or kind of aggregate is required, 2 weigh beams will be permitted. The scale shall be provided with suitable lockouts so that the weigh beams may be engaged to weigh in the desired order. Each weigh beam shall have some means or device to indicate when the beam is in the proper balance position. Poises shall be constructed so that they will be held firmly in position. Beam scales shall have provisions such as a "telltale" dial for indicating to the operator that the required load in the hopper is being approached. Such device shall indicate at least the last 90 kg (200 lbs.) of load in the case of scales used for weighing aggregate, and at least the last 45 kg (100 lbs.) of load in the case of scales used for weighing cement, and shall be placed in a position from which it can be viewed without parallax by the operator while charging the hopper.

Except in the case of commercially established ready-mixed concrete plants, springless dial scales shall be provided with suitable markers inside the glass cover and in front of the dial which may be set to show the position of the dial indicator for the required load or the various accumulative loads when more than one size or kind of aggregate is weighed in the same hopper. Markers shall have distinctive colors for the various materials to be weighed. Dials shall be placed so that they can be viewed without parallax by the operator.

The value of the minimum graduation interval of any scale used for weighing aggregates or cement shall be not more than 0.2 percent of the batch mass (weight) and not more than 0.1 percent of the capacity of the

scale, except that graduation intervals less than 2 kg (5 lbs.) when weighing aggregates and less than 1 kg (2 lbs.) when weighing cement will not be required. In the case of beam scales, the same requirement shall also apply to the graduation of each individual beam with respect to the mass (weight) of material normally weighed on it. The value of the minimum graduation interval of any scale used for weighing mixing water shall be not less than 1 kg (2 lbs.). All scales shall be designed and built so that an accuracy within the maximum tolerance of 0.4 percent of the net load in the hopper will be maintained.

Cement shall be weighed on a scale separate and distinct from the scale or scales used for weighing other materials. Mixing water, when weighed, shall be subject to the same requirement. When a beam scale is used for weighing cement, a tare beam shall be provided and the weigh beam or beams shall be capable of being lifted out of weighing position so that the tare mass (weight) of the hopper can be checked after each weighing operation to determine if all of the cement has been discharged into the batch.

Scales shall be housed or otherwise protected against the effect of wind in a manner meeting the approval of the Engineer.

Ten standard 25 kg (50-lbs.) weights meeting the requirements of the National Institute of Standards and Technology shall be available on the job site for use in calibrating and testing the weighing equipment. The weights will not be required when the scales are calibrated by reputable, trained scale personnel with adequate scale testing equipment and the calibration is observed by the Engineer.



Means of access for inspection purposes shall be safe and shall meet the approval of the Engineer. In the case of permanently located batching plants, the means of access shall be an inclined stairway with handrail located so that its upward flight will end on the scale operator's platform. It shall be firmly attached to the supporting members of the bin. The weigh platform shall have an approved floor of metal grid or 50 mm (2-inch) plank.

**1103.03 Automatic and Semi-Automatic Batching Equipment.** Automatic equipment for weighing, measuring, batching and mixing materials for portland cement concrete, shall be approved by the Engineer, and shall conform to Articles 1103.01 and 1103.02, except as follows:

(a) General Requirements. It is the purpose of the requirements set forth herein that automatic and semi-automatic batching shall render impossible the omission of any one of the required materials from any batch, and that duplications of measurement of any one material into any batch shall not occur. Further, it is the intent that the amounts of materials entering into any batch shall be accurately measured within the specific tolerances set forth herein. In the case of central mixing plants, it is intended that each batch shall be mixed during the full period required after all the materials have entered the mixer, and that recharging the mixer shall not occur before the previous batch has been discharged. Certain requirements to further the objects stated are as follows:



 Allowable Tolerances. The cement shall be weighed, and the mixing water weighed or otherwise measured, within the tolerance of 1 percent of the required quantity. Each of the aggregates, whether measured separately or cumulatively, shall be measured within the tolerance of 1 1/2 percent of the respective required weights. No specific tolerance can be applied to the measurement of air entraining admixture, except that the amount added shall produce the air content specified for the concrete. The interlocks shall be set so that the quantities of the materials will be delivered within the tolerance stated.

- (2) Weighing Control. Arrangement shall be such that any scale of the system can be conveniently checked for accuracy at any time that this should be considered desirable. All scales shall be designed and built so that, when any drag due to weighing control devices is included, an accuracy within the maximum tolerance of 0.4 percent of the net load in the hopper will be maintained.
- (3) Water Measuring Control. When the mixing water is measured volumetrically, provisions shall be made for bypassing the measured water into a container for checking the accuracy of delivery. If the water is measured during the course of its flow into the batch, means shall be provided to show, at any time during the flow, the amount that has entered. Devices for volumetric measurement of mixing water, in the case of automatic systems, shall automatically reset at the initial position immediately after delivery of the measured amount, ready for the next succeeding batch cycle.



- 4) Air-Entraining Admixture Control. The dispenser for air-entraining admixture shall meet the requirements for automatic or semi-automatic batching. In order to provide a visual indication at all times that the admixture is actually entering into the batch, the tube through which it is conducted into the stream of mixing water shall be transparent or translucent, or shall have a transparent or translucent section.
- (5) Control of Mixing Time. When automatic or semi-automatic batching plants, in connection with central mixing, are used for successive batches of the same size, the mixing time adjusting control shall be capable of being locked with a key.
- (b) Automatic Batching Equipment. Automatic batching equipment shall be provided with gates, valves, or other suitable devices, which, when activated by a single starting mechanism, shall set in motion the charging of weigh hoppers or other containers, and which, in weighing or measuring any given material, shall automatically stop the flow of that material when the desired amount, within the allowable tolerance, has been attained. Automatic batching equipment shall be capable of having quantities preset on a central control panel that will result in correct measurement of each material for each batch, and control adjustments shall be capable of being performed on that panel.

For any material measured by weight, a suitable "over" and "under" indicating device shall be provided, showing whether the amount of material weighed is within the allowable tolerance. Interlock shall be provided (1) so that the charging device can open or start only when the scale indicates zero load and when the weigh hopper or container discharging gate or valve is closed, and (2) so that the discharging gate or valve can open only when the desired mass (weight) within the allowable tolerance is in the weigh hopper or container and when the charging device is closed or stopped. If different kinds or classes of aggregates are weighed cumulatively into the same hopper, control and interlock shall be provided with respect to each

increment of weighing, as required for a material weighed into an individual hopper. It shall not be mandatory that the mixing water and air-entraining admixture be measured by weighing. These materials may be measured volumetrically, if the specified controls, or other equally effective means are provided, and if the measurements are within the specified tolerance.

Automatic batching equipment for weighing or measuring batch quantities in increments shall be provided with an automatic repeater having a counter that can be set for the number of increments required, and which shall ensure that the required number of increments are accurately delivered and discharged into each batch.

An automatic batching system shall consist of the combination of automatic batchers necessary for batching the materials required. All shall be activated by a single starting mechanism and the system shall be completely interlocked. In the case of central mixing plants, interlock shall be provided so that the discharging gates or valves can open only when the mixer is in the proper position for receiving the materials. The interlock of the system, with respect to sequence of discharge of the materials into the mixer, shall be such that the mixing water and air-entraining admixture are discharged according to the requirements of Articles 1020.08 and 1020.11.

Means shall be provided for convenient adjustment, from preset quantities, of the amounts of the aggregates, the mixing water and the air-entraining admixture, as based on tests of the aggregates and observations and tests of the concrete mixture being produced. Suitable equipment indicating the amount of free water in the fine aggregate, as it is being batched, shall be provided, and the quantities of fine aggregate and mixing water shall be adjusted currently, as concrete is being produced, so that the desired amounts of these materials enter into each batch. Other adjustments of the quantities, as preset for automatic control, shall be made only at the direction of the Engineer.

The weighman shall not interfere with the operation of any part of the scale mechanism during the weighing process for the purpose of circumventing the interlock or malfunction of the equipment. Failure to comply with this requirement shall be cause for the Engineer to require that the equipment be provided with a positive means for preventing such interference.

A batching system consisting of a combination of semi-automatic batchers, as described below, and automatic batchers may be approved, provided that control and interlock shall be as prescribed for automatic batchers.

(c) Semi-automatic Batching Equipment. Batching equipment which does not substantially comply with all the requirements prescribed for automatic batching equipment, but which meets at least the following described minimum conditions, will be considered as semi-automatic batching equipment.

As a minimum requirement, semi-automatic batching equipment shall be provided with gates, valves or other suitable devices, which open or start separately, when actuated by individual starting mechanisms, to permit the material to be weighed or measured, and close or stop automatically when the desired amount, within the allowable tolerance, has been attained. Interlock with respect to individual units and "over" and "under" indicating devices shall be provided as prescribed for automatic batching equipment.

Other features prescribed for automatic batching equipment may be incorporated and approved.

A semi-automatic batching system shall consist of the combination of semi-automatic batchers necessary for batching the materials required. The system may be partially or completely interlocked.

For semi-automatic batching systems constructed so that materials are batched at more than one stop or location, a separate control panel shall be furnished at each location, unless the operations can be controlled from a central location in a manner that will ensure that the correct amount of material is included in each batch. In the event that movement of vehicles receiving the batches is necessary during the operations at any location, a separate control panel shall be provided at that location, and an operator shall be present to ensure that the batches are discharged correctly into their respective compartments. However, if effective interlock is provided between the movement of vehicles and the batching mechanism so that batches can be discharged only as required without omission or duplication, and as each batch compartment is brought into correct position, then the operations may be conducted from a centrally located control panel.

The weighman shall not interfere with the operation of any part of the scale mechanism during the weighing process for the purpose of circumventing the interlock or malfunction of the equipment. Failure to comply with this requirement shall be cause for the Engineer to require that the equipment be provided with a positive means for preventing such interference.

A batching system consisting of a combination of semi-automatic and manual batchers may be approved, provided that satisfactory control of the batching is attained.

(d) Manual Operation. Automatic and semi-automatic batching equipment may be constructed so that they can be switched to manual control. When switching to manual control is necessary, the batching operations shall continue only until repairs can be made, but not for a period exceeding 72 hours, unless otherwise approved by the Engineer.

If provision is made for switching to manual operation, then the scale, or a scale follower approved by the Engineer, shall be placed within easy view of the operator, but not farther than 6 m (20 ft.) from the location from which the manual batching is being performed. Dial scales shall be placed so that they can be viewed without parallax.

**1103.04 Mobile Portland Cement Concrete Plants.** The mobile concrete plant shall meet the following minimum requirements:

- (a) The mixer shall be capable of carrying sufficient unmixed materials to produce not less than 4.6 m<sup>3</sup> (6 cu. yds.) of concrete.
- (b) The mixer shall be capable of positive measurement of cement being introduced into the mix. A recording meter visible at all times and equipped with a ticket printout shall indicate this quantity.
- (c) The mixer shall provide positive control of the flow of water into the mixing chamber. Water flow shall be readily adjustable for variations in aggregate moisture.

# Art. 1103.04 Portland Cement Concrete Equipment

- (d) The mixer shall be capable of being calibrated to automatically proportion and blend all components on a continuous or intermittent basis, as required by the finishing operation, and shall discharge mixed material through a conventional chute.
- (e) The mixer shall be calibrated annually by a commercial testing laboratory. Copies of calibration charts shall be maintained in the truck and also the District office.
- (f) The mixer shall be maintained clean and in good repair.
- (g) The mixer shall meet all requirements of AASHTO M 241.

#### 1103.05 Forms.

(a) Pavement. Flexible or curved forms of proper radius, made of either metal or wood, shall be supplied for use on curves of 30 m (100 ft.) radius or less.

At all other locations, unless approved by the Engineer, side forms for pavement shall be metal. They shall be of an approved cross section, and shall be furnished in sections not less than 3 m (10 ft.) in length. They shall have a height not less than the edge thickness of the pavement to be constructed, a base width equal to or greater than the height and shall be made of metal not less than 6 mm (1/4 inch) in thickness, except that a minimum thickness of 5 mm (3/16 inch) will be permitted if the form is of trapezoidal cross section. They shall have flange braces extending outward on the base not less than 2/3 the height of the form and spaced not more than 1.5 m (5 ft.) apart. Each section shall have a steel pin at each end and at least one intermediate pin, and provision shall be made to lock all pins to a true grade. Locked joints shall be provided between form sections to maintain the alignment and elevation of the form line. Metal forms shall withstand loading imparted by the paving train without distortion or settlement of the form line. They shall be straight and free from warp. Any form varying on its upper edge more than 2 mm (1/16 inch) in 3 m (10 ft.) from a straight line will be rejected. The longitudinal axis of the upstanding leg shall not vary more than 6 mm (1/4 inch) in 3 m (10 ft.) from a straight line.

The use of wood forms will not be permitted unless approved by the Engineer. When used, wood forms shall be made of well seasoned, surfaced plank, shall be not less than 50 mm (2 inches) thick (commercial dimensions), with the exception of curved or flexible sections, and shall be the full depth of the concrete slab; shall be straight and free from warp; shall provide for rigid, smooth connections; and shall provide ways and means to be securely fastened in place to the lines and grades given.

Metal forms that will be used to support a vibrating screed shall be made of no less than 3.4 mm (10 gauge) steel with a minimum 100 mm (4-inch) wide base and have a minimum of 2 flange braces with provisions for pin locking in each 3-m (10-ft.) section.

Metal pins shall be of proper size and length to hold the forms rigidly and securely in place.

Metal forms may be built-up with a single layer of wood plank, 50 mm (2 inches) thick or less when the specified pavement thickness differs from

- standard manufacturered form sizes. The wood plank shall be well seasoned surfaced hardwood free from warp and twist. The plank shall be attached to the bottom of the metal form with two lines of bolts at not more than 600 mm (2 ft.) centers on each line. The width of the plank shall equal or exceed the pavement thickness.
- (b) Concrete Gutter, Curb, Median and Paved Ditch. The forms shall be of wood or metal, straight and free from warp, and of sufficient strength to resist springing during the process of depositing the concrete against them. Wood forms shall consist of 50-mm (2-inch) surface plank, except wood forms less than 50 mm (2 inches) thick may be used for short radii. Metal forms shall be of an approved section and shall have a flat surface on the top. Forms shall be so designed that divider plates or other devices for holding the form in place will not cause planes of weakness in the concrete and subsequent cracking. The forms shall be of a depth of the curbing, median or paved ditch, and so designed as to permit secure fastening together at the tops.
- **1103.06 Form Grader.** The mechanical form grader shall be so designed that it may be adjusted and controlled to cut to a given grade and produce a subgrade for the pavement forms or for slip-form paver tracks as required by the plans.
- **1103.07 Mechanical Form Tamper.** The mechanical form tamper shall be of an approved design which will compact the subgrade material under the forms to the satisfaction of the Engineer.
- **1103.08 Subgrade Planer.** The subgrade planer shall be of steel and be mounted on rollers or wheels. It shall be equipped with steel cutting edges or cutting rollers, so designed that they may be accurately adjusted vertically. The subgrade planer shall be of sufficient mass (weight) so as not to rise from the pressure of the material being planed. The subgrade planer shall produce a cross section in accordance with the plans and shall not develop a center deflection of more than 3 mm (1/8 inch).
- 1103.09 Subgrade Machine. The subgrade machine shall be self-propelled and mounted on crawler type tracks. It shall be equipped with a rotating drum fitted with cutting teeth capable of cutting and trimming earth, aggregate and bituminous mixtures, and so designed that they may be accurately adjusted vertically and held in place. The machine shall have a moldboard to provide the final surface and texture. It shall weigh not less than 3200 kg (7000 lbs.) and shall have such strength and rigidity that it will not develop a center deflection of more than 3 mm (1/8 inch).

The subgrade machine shall be equipped with an automatic electronic grade control device. The device shall be capable of controlling the elevation of the subgrade machine relative to either a preset grade control stringline or a traveling grade reference. The method of grade control shall be approved by the Engineer.

The subgrade machine shall also fulfill the requirements for a heavy subgrade template where applicable.

**1103.10 Heavy Subgrade Template.** The heavy subgrade template shall be made of steel, and shall be designed so that it can be moved backward and forward in a vertical position. It shall be mounted on visible rollers, wheels or tracks, shall be adjustable vertically, and its total mass (weight) shall be not less than 225 kg (500 lbs.) for widths of 5.5 m (18 ft.) or more. The test points shall be spaced not more than 150 mm (6 inches) center-to-center, and shall be adjustable so that they may

be set to conform to the cross section of the subgrade. The Contractor shall be responsible for keeping this template adjusted to proper shape.

- **1103.11 Water Supply Equipment.** The water supply equipment shall be of such capacity and design as to ensure an ample supply and adequate pressure simultaneously for all of the requirements of machinery, mixing, curing, wetting subgrade and all other features of the work.
- 1103.12 Mechanical Concrete Spreader. The mechanical concrete spreader shall be approved by the Engineer. The spreader shall run on forms when forms are used or on wheels or tracks when slip forming. The mechanical concrete spreader shall be self-propelled and shall be capable of spreading the concrete mix to the desired cross sections. The spreader shall be easily adjustable to spread different elevations of concrete. Vibrators may be attached to the spreader, finishing machine or may be mounted on a separate carriage and shall not come in contact with the joints, load transfer devices, reinforcement, subgrade, subbase, or side forms.

The vibrating impulses shall be applied through an apparatus especially designed for this purpose and so constructed as to operate satisfactorily ahead of the finishing machine in such a manner that the vibratory impulses are transmitted through the concrete mass with sufficient intensity to consolidate it throughout its entire depth and width. Vibrators shall not be used to level or spread the concrete, but shall be used only for purposes of consolidation.

Surface pan type vibrators shall be so designed that the vibrating impulses will be applied directly to the surface of the concrete. The surface pan type vibrator shall be equipped with a minimum of 2 vibrating elements for each lane width of pavement vibrated. The operating frequency shall be not less than 3500 impulses per minute.

Vibrators of the internal type shall be especially designed for this purpose and so constructed as to operate satisfactorily. The operating frequency of the internal type shall be not less than 7000 impulses per minute. The vibrating elements shall be so spaced that the concrete mass will be consolidated throughout its entire depth and width, but the spacing of the vibrating elements shall not exceed 600 mm (24 inches).

A vibrating reed tachometer, hand type, shall be furnished with each paver. The vibrating reed tachometer shall have a range from at least 7000 to 11000 VPM.

#### 1103.13 Finishing Machine.

- (a) Bridge Deck. The finishing machine shall be equipped with: (1) a mechanical strike off device; and (2) either a rotating cylinder(s) or a longitudinal oscillating screed which transversely finishes the surface of the concrete. The Contractor may attach other equipment to the finishing machine to enhance the final finish when approved by the Engineer. The finishing machine shall produce a floor surface of uniform texture, free from porous areas, and with the required surface smoothness.
  - The finishing machine shall be operated on rails or other supports that will not deflect under the applied loads. The supports shall be adjustable for elevation and shall be completely in place for the full length of the area to be finished. The supports shall be approved by the Engineer before placing of the concrete is started.
- (b) Pavement. The finishing machine shall be designed for concrete paving and meet the approval of the Engineer. The finishing machine shall be

power driven with at least two oscillating screeds or a pan type screed which shall be capable of placing, spreading, consolidating, screeding and finishing the concrete to the proper pavement elevation and cross section within the specified tolerance.

The pan type paver shall be equipped with augers, strike off and tamper bars ahead of the pan screed with at least one trailing oscillating screed or belt finisher. The pan shall be sufficiently braced and stiffened to ensure no deflection. Internal vibrators with pressure compensating controls meeting the requirements of Article 1103.12 shall be attached to the paver. If the paver is powered by cable and motor, a steering sensor shall be required and the motor shall be hydraulically operated. One switch or control, which stops or starts all paver functions simultaneously shall be provided.

Power driven finishing machines, exclusive of vibratory screeds and truss-type vibratory screeds, which do not conform to the above requirements, which are specifically designed for finishing concrete pavement or bridge decks and meets the approval of the Engineer, may be used under the following conditions:

- (1) Restricted clearance outside the forms.
- (2) Mainline pavements with a posted speed of 65 km/h (40 mph) or less.
- (3) Where a continuous line of forms more than 180 m (600 ft.) cannot be set. Entrance gaps, manholes, catch basins and other small fixtures shall not be construed as obstruction to continuity of the form line. Railroad tracks, bridges, existing paved intersections or gaps shown in the plans or ordered by the Engineer shall be considered as obstructions in the continuity of the form line.
- (4) Bridge Approach Pavement, Shoulder Pavements and Connections
- 1103.14 Concrete Finisher Float. The concrete finisher float shall be either self-propelled or attached to a finishing machine. It shall be equipped with independent wheels which ride on the forms and it shall be of sufficient mass (weight) as to not flex under the pressure of the concrete. The float shall be easily adjustable from crown to flat. The float shall be a minimum of 750 mm (30 inches) in length with a minimum of 600 mm (24 inches) in contact with the concrete. It shall be selsigned to prevent tearing of the concrete surface or rolling of aggregate under the float. The float pan shall be suspended from the frame, float freely on the concrete, and shall be capable of being adjusted in both height and width. The float pan, once adjusted, shall be equipped hydraulically or by other suitable means that it may be raised from the operator's platform and when lowered shall automatically return to its preset position.
- **1103.15 Mechanical Longitudinal Float.** The machine shall be so constructed that the travel of the floating mechanism can be adjusted to conform to the pavement cross section shown on the plans or formed by the finishing machine.
- 1103.16 Formless Paver. The formless paver shall be self-propelled, shall be equipped with suitable devices for distributing, finishing and spreading concrete full-width and depth as shown on the plans. The tracks shall be of sufficient length and width to properly support the machine and its load without causing excessive depressions. The formless paver shall be equipped with strike off screed, and internal vibrators of sufficient quantity to provide complete consolidation regardless of the

depth of concrete placed. Vibrators shall meet the requirements of Article 1103.12. The paver shall be capable of constructing pavement to line and grade specified. The method of placing the concrete in front of the formless paver shall be a separate operation as specified in Article 1103.12 and shall not be attached to the formless paver.

# 1103.17 Miscellaneous Equipment.

- (a) Hand Vibrator. The vibrator shall be the internal type. adequately powered to operate under full load at a frequency of not less than 4500 cycles per minute; and shall have an intensity and period of vibration sufficient to obtain thorough consolidation of the concrete.
- (b) Hand Tamper. Hand tampers, when required or permitted under these Specifications, shall meet the approval of the Engineer.
- (c) Header. The header shall be shaped to conform to the cross section required by the plans. It shall be wood or metal and of sufficient thickness and rigidity to provide a vertical construction joint. The header for continuous reinforced pavement shall be of wood or metal and shall be split longitudinally to provide for the proper depth of the continuous reinforcement steel according to the plans.
- Foot bridges shall be durably constructed and readily movable. They shall be so designed that no part of the bridge will come in contact with the pavement at any time. Two or more foot bridges shall be provided.
- (e) Longitudinal Float. The hand operated longitudinal float shall be of approved design, not less than 3.5 m (12 ft.) in length and 150 mm (6 inches) in width. The float shall be properly stiffened to prevent flexing and warping, and shall be provided with handles.
- (f) Long-Handled Float. The long-handled float shall have a blade not less than 1 m (3 ft.) in length and 150 mm (6 inches) in width. The handle shall be of such length as will permit the operation of the float from the shoulder. Two or more such floats shall be provided.
- (g) Vibrating Screed. The screed used to strike off and consolidate the concrete by the hand method shall be durably constructed, equipped with a vibrator, and shall be shaped to provide the cross section required by the plans. It shall be 600 mm (2 ft.) longer than the width of the pavement, sufficiently strong and rigid to retain its shape under all working conditions, and shall be provided with handles. If of wood, it shall be not less than 75 mm (3 inches) thick and shall be steel shod.
- 3-m (10-ft.) Straightedge. The 3 m (10-ft.) straightedge shall be made of suitable material, and shall be maintained in accurate alignment at all times. It shall be equipped with a handle of such length as to permit operation of the straightedge from the shoulders. Two or more 3 m (10-ft.) straightedges shall be provided.
- (i) Broom. Brooms shall be of push broom type, not less than 450 mm (18 inches) in width. They shall contain not more than 3 rows of good quality bass or bassine fiber not more than 115 mm (4 1/2 inches) in length. The handle shall be not less than 300 mm (1 ft.) longer than 1/2 the width of the slab, and shall be readily adjustable. Two or more brooms shall be provided.

(j) Edging Tool. The edging tools shall have a radius of 6 mm (1/4 inch), and shall be approved by the Engineer. Two or more edging tools shall be provided.

# SECTION 1104. CEMENT OR POZZOLANIC AGGREGATE MIXTURE EQUIPMENT

**1104.01 Mixing Plant.** The cement or pozzolanic aggregate mixture plant shall be a batch or continuous type mixing plant. The plant units shall be so designed, coordinated, and operated that they will produce mixtures within the tolerances specified. The plant units shall meet the following requirements:

- (a) General. All plants shall be approved by the Department before production begins. Plants not meeting the conditions herein specified may, upon request, be granted a conditional waiver to operate, provided satisfactory evidence is presented that the required modifications are in progress. This conditional waiver will be terminated on November 1 of the year in question and shall not be renewed for any succeeding year.
- (b) Safety, Calibration, Inspection Requirements. The plant shall be equipped with safe, unobstructed walkways and stairways, to all sampling points and the mixer platform. Accessibility to the top of the truck bodies shall be provided by a platform or other suitable device. All gears, pulleys, chain sprockets and other dangerous moving parts shall be equipped with guards. Suitable devices shall be provided to enable the Engineer to obtain samples, raise scale calibration equipment, sampling equipment or other equipment from the ground to points of sampling.
- (c) Laboratory. Each plant shall be provided with a laboratory, equipped to perform such tests as are necessary for quality control or assessment of the mixture. This laboratory shall be located in the same building as the plant operator, or in a separate building located within 60 m (200 ft.) of the plant operator.

Each laboratory shall be provided with adequate lighting, heating, air conditioning, electrical outlets (110 v. service), running water, and a telephone. Furnishings shall include a desk, chair, sink and  $0.9 \times 0.9 \times 3$  m (3 x 3 x 10') work-bench. Safety and sanitary facilities, including fire extinguisher, first-aid equipment and toilet facilities shall be available on the premises.

The following testing equipment shall be furnished by the producer as part of the laboratory facilities:

# Cement or Pozzolanic Aggregate Mixture Equipment

1 balance capacity of 0-2500 g complete with appropriate weights

1 set of sieves, 200 mm (8 inches) diameter, consisting of the following sizes:

37.5 mm (1-1/2"), 25.0 mm (1"), 12.5 mm (1/2"), 9.5 mm (3/8"), 4.75 mm (No. 4), 2.36 mm (No. 8), 2.00 mm (No. 10), 425 μm (No. 40), 75 μm (No. 200), complete with pan and cover.

1 mechanical sieve shaker and timer.

1 oven with controllable temperature from 23±1 °C to 110±5 °C (73±2 °F. to 230±9 °F.)

1 small sample splitter, riffle type, complete with pans.

1 large sample splitter, riffle type, complete with pans.

1 compaction base as required in AASHTO T 180, Article 4.2.

- (d) Storage Facilities. Sufficient space shall be provided for storage of each ingredient material type. If necessary to prevent the intermixing of the different materials in adjacent stockpiles, suitable partitions shall be used between the stockpiles. All aggregates shall be kept separated until they are fed in their proper proportions onto a belt conveyor. Aggregates shall be handled in such a manner as to prevent contamination and degradation. Lime, cement, or fly ash shall be stored separately in such a manner that caking, cementing and bulking due to moisture will be minimized prior to introduction into the mix. Storage bins, silos or compartments shall be equipped with warning devices at the lower 1/4 points, which will visually or audibly alert the operator, during production, of a low level condition. A scalper or other device that will remove large lumps of clay, aggregate or fly ash shall be installed at the top of fly ash and aggregate bins.
- (e) Crane or End Loader. The crane used in stockpiling the aggregates or conveying the aggregates to the aggregate feeders shall be in good mechanical condition. When compartment aggregate bins are used, the width of the crane bucket shall be not more than one-half the minimum width of the top of the bin compartments, and the maximum length of the bucket when fully open shall be at least 300 mm (1 ft.) less than the length of the top of the bin compartment or extensions.

When an endloader is used to charge bins, the maximum discharge width of the bucket shall be 600 mm (2 ft.) less than the width of the top of the bin.

(f) Calibration/Calibration Checks of Lime, Fly Ash, Cement, and Aggregate Feeds. Initial calibration of aggregate and/or fly ash shall be accomplished separately, by weighing truckload increments discharged through the mixer. Provision shall be made for diversion of lime in smaller increments acceptable to the Engineer, into appropriate test weight containers, prior to introduction into the mixer.

Calibration checks during production may be performed in smaller quantities, acceptable to the Engineer, of each or all components. Plants equipped with weight belts, for any or all mix ingredients, will require diversion and/or separate weighings of ingredients only during initial calibration, unless required as a result of scale repair or readjustment. Feeders for each ingredient shall be equipped with revolution counters,

mechanically connected to a shaft. Calibration and spot checks of all components shall be performed under normal operating conditions of belt speed, and bin or silo head.

The plant shall be equipped to handle and weigh test weight samples and containers. Platform scales of capacity up to 160 kg (350 lbs.), for weighing lime and check calibration samples shall be of certified accuracy, or otherwise checked for accuracy in the presence of the Engineer using 25 kg (50-lbs.) test weights. The Contractor (producer) shall also provide truck scales of certified accuracy for weighing of truckload increments.

(g) Proportioning of Lime, Fly Ash, Cement and Aggregate. The plant shall be equipped with accurate means of feeding, by mass (weight) or volume such amounts of lime, flyash, cement and aggregate(s) as are required by the mixing formula and within those tolerances specified for pozzolanic aggregate and cement aggregate mixtures. If proportioned volumetrically, each ingredient bin or compartment shall have an accurately controlled gate which shall be bolted or otherwise fixed in position during plant operation. If proportioned by mass (weight), each ingredient feed shall be mechanically or electrically controlled so as to automatically maintain present feed rates.

Provisions shall be made so that complete malfunction of any single component feed will initiate an audible or visual warning to the operator until such deficiency is corrected. Warning override shall be effected only for the purpose of mixer clean-out during plant operation.

- (h) Mixing Water. Water may be proportioned either by weight or volume. An appropriate indicator reading in L/min. (gal. per min.) or kg/min. (lbs. per min.) visible to the operator shall continuously indicate the rate at which water is being discharged into the mixture.
- (i) Mixer. The plant shall include a continuous or batch mixer capable of producing a uniform mixture within the job-mix tolerances. Continuous mixers which discharge directly into trucks shall be equipped with discharge/surge hoppers large enough to permit changing trucks without shutting down the plant. Mixers discharging into surge silo transfer conveyors or elevators will not be required to have discharge hoppers.

Mixer paddles shall be adjustable or reversible, to advance or retard mixture flow. If, in the opinion of the Engineer, adequate mixing is not being obtained, the Engineer may require that an adjustable baffle or dam, which can be locked or bolted in position, shall be installed at the discharge end of the mixer. The mixer shall have attached, a manufacturer's plate giving the net volumetric contents of the mixer at the several depths.

 Platform Truck Scale for Weighing Cement or Pozzolanic Aggregate Mixtures. Cement or pozzolanic aggregate mixtures shall be measured on platform scales according to Article 1102.01(c)(5).

#### **SECTION 1105. PAVEMENT MARKING EQUIPMENT**

**1105.01 Thermoplastic.** The material shall be applied to the pavement by an extrusion method where one side of the shaping-die is the pavement or by means of an extended ribbon. If used, the shaping-die should be equal to the width of the line

specified in the plans. The method used shall produce sharp edges on both sides and square ends on each stripe. The use of pans, aprons, or similar devices to prevent die overruns will not be permitted.

The Contractor shall provide an accurate temperature measuring device capable of measuring the pavement temperature prior to installation of the thermoplastic and the temperature of the molten thermoplastic material immediately after it is applied.

- (a) Truck-mounted. The equipment shall be permanently mounted on a truck of sufficient size and stability with an adequate power source to insure smooth, straight application and capable of maintaining a continuous operating speed of at least 5 km/hr (3 mph). The truck shall be equipped to carry a minimum of 1,800 kg (4,000 lbs.) of molten thermoplastic. The mounting shall allow the extrusion equipment to accurately follow road irregularities and produce lines of uniform dimensions.
  - The application equipment shall be capable of automatically placing intermittent and continuous lines of the various widths and colors of pavement marking lines specified.
- (b) Hand-operated. The Engineer may permit the use of a hand-operated machine for those locations where only a limited quantity of lane and edge lining is required. Words, symbols, and lines other than edge lines may be placed with a hand-operated machine capable of containing a minimum of 55 kg (125 lbs.) of molten material. For the purpose of these specifications, "hand-operated" shall also include any riding units not considered as "truck-mounted".
- **1105.02 Epoxy.** The epoxy pavement marking compounds shall be applied through machinery designed to precisely meter the two components in the ratio of 2:1. This equipment shall produce the required amount of heat at the mixing head and gun tip and maintain those temperatures within the tolerances specified. This machinery shall also have as an integral part of the gun carriage, a high pressure air spray capable of cleaning the pavement immediately prior to the marking application.

The equipment shall be capable of spraying both yellow and white epoxy, according to the manufacturer's recommended proportions and be mounted on a truck of sufficient size and stability with an adequate power source to produce lines of uniform dimensions and prevent application failure. The truck shall have at least two epoxy tanks each of 415 L (110 gals.) minimum capacity and be equipped with hydraulic systems and agitators. It shall be capable of placing stripes on the left and right sides and placing two lines on a three-line system simultaneously with either line in a solid or intermittent pattern, in yellow or white, and applying glass beads by the double drop pressurized bead system at a rate of 1.2 kg per L (10 lbs. per gal.). All guns shall be in full view of operators at all times. The equipment shall have a metering device to register the accumulated installed quantities for each gun, each day. Each vehicle shall include at least one operator who shall be a technical expert in equipment operations and epoxy application techniques. Certification of equipment shall be provided at the preconstruction conference.

#### SECTION 1106. TRAFFIC CONTROL EQUIPMENT

**1106.01 Truck Mounted Attenuators.** The attenuator shall be an approved unit that has been successfully crash tested with vehicles weighing 1000 to 2200 kg (2200 to 4800 lbs.) and impacting the unit at 70 km/h (45 mph).

**1106.02 Shadow Vehicles.** The shadow vehicle required for the truck mounted attenuator shall have a minimum gross vehicle weight rating of 12,250 kg (27,000 lbs.).

**1106.03 Arrow Boards.** Arrow boards shall be used where shown on the plans or as directed by the Engineer. Minimum legibility distances are those at which the arrow board can be comprehended by a driver on a sunny day or clear night.

Arrow boards shall be rectangular, of solid construction, and finished with nonreflective flat black. The boards shall be mounted as shown on Standard 702001. Remote controls should be provided with roof mounted arrow boards.

Arrow boards shall have the capability of the following mode selections: (1) left or right flashing shaft with arrow point; (2) flashing shaft with double arrow points; and (3) caution. The arrow point shall be composed of at least 5 lamps at an angle of 35 to 60 degrees measured from the horizontal shaft which shall be composed of at least 3 lamps. Shafts in the double arrow point mode shall be composed of at least 2 lamps for Type A units and 3 lamps for Type B and C units. The caution mode shall consist of 4 or more lamps, arranged in a pattern which will not indicate a direction. The lamps or lenses shall be recess mounted or alternately equipped with an upper hood of not less than 180 degrees, and the color emitted shall be yellow. The lamps shall be 12 volt, water proof units, consisting of LED, Halogen or sealed incandescent beams, spaced so as to substantially fill the board. Lamps shall be capable of a minimum of 50 percent dimming from their rated voltage. The flashing rate shall not be less than 25 nor more than 40 flashes per minute. Minimum lamp on time, shall be 50 percent (no lamps shall remain illuminated during "off" time). All units shall have a permanently-mounted voltmeter indicating the voltage available to the lamps. Trailer mounted units shall be equipped with a minimum of 2 indicator lamps on the near side of the arrow board.

Arrow Board Type:	А	В	С
Minimum Lamp Size Minimum Number of Lamps Minimum Legibility Distance		PAR 36 13	PAR 46 15
Meters Miles	800 1/2	1200 3/4	1600 1

The power to operate the arrow board may be supplied from self-contained batteries, (with or without a solar panel generator), a vehicles' electrical system, a gasoline or diesel fueled generator, or an external power source. Where batteries are used as the primary power source, they shall be capable of providing sufficient voltage, between charging, to each of the lamps for a period of at least 72 continuous hours or operation, in any mode at full daylight intensity. Units utilizing gasoline or diesel fueled generators or an external power source shall be equipped with storage batteries wired so the unit will automatically switch to battery power in the event of failure of the primary power source. The batteries shall be capable of providing sufficient capacity to the lamps for at least 3 continuous hours of operation in any mode at full daylight intensity.

Where an external power source is used, the cable placement shall meet the approval of the Engineer, and all electrical codes applicable to the area shall be observed. When greater than 24 volts is supplied externally, the service cable shall be fused at a location sufficiently removed from the unit so as to leave no live wires exposed at or near the unit in the event of a vehicular collision.

Trailer-mounted units shall be equipped with a photoelectrically operated switch

capable of varying the lamp voltage from 6 volts for nighttime use to 12 volts for daylight use. This switch shall not be capable of manual operation. Failure of this switch shall cause the lamps to operate in the dim mode (6 volt) only. Roof-mounted units may be equipped with a manually operated voltage control switch.

1106.04 Sign Trailers. Small, lightweight trailers may be used as temporary supports for construction and maintenance signs where post mounted signs are not required by the Highway Standards. The trailer, exclusive of signs, flashing light and batteries, shall be no more than 135 kg (300 lbs.) and shall not be fabricated with heavier than 75 x 75 mm (3 x 3 inch) angles, 63 mm (2 1/2 inch) diameter pipes, or 75 x 50 mm (3 x 2 inch) rectangular tubing. The rim size of the wheels should not exceed 300 mm (12 inches). Automotive or truck rear axle assemblies with differential housings shall not be used. In the erected position, the tires may rest on the ground or be elevated with the bottom of the tires no greater than 150 mm (6 inches) above the ground. No weights other than sandbags shall be used and any sandbag or large batteries for the flashing lights shall rest no higher than 300 mm (12 inches) above the ground. Wheel chocks other than sandbags shall not be used. The tongue may be pinned to the ground (or a paved area if approved by the Engineer) to reduce wind-induced rolling. Such a pin shall be designed to readily pull or break in the event of a vehicular impact. the method of pinning shall be approved by the Engineer.

Each end of the rear rail of the trailer shall be equipped with a 75-mm (3-inch) diameter or equivalent red reflector.

Except when the sign trailer is actually being moved, it shall be detached from the towing vehicle and the towing vehicle parked as prescribed in Article 701.04. During nonworking hours, trailers with signs that do not apply to existing conditions shall also be in accordance with Article 701.04.

# APPENDIX METRIC INFORMATION

<u>Definitions:</u> Soft Conversion is an exact conversion of the English Unit. Hard conversion is a close approximation of the English unit but is rounded logically in the metric system.

Basic Units				<u>Prefixes</u>	
millimeter meter square meter cubic meter liter  Pascal kilopascal	(mm) (m) (m <sup>2</sup> ) (m <sup>3</sup> ) (L) (Pa) (kPa)		deci (d) centi (c) milli(m) micro (µ) nano (n) deca (da) hecto (h) kilo (k) Mega (M)	10-1 10-2 10-3 10-6 10-9 101 102 103 106	one tenth one hundreth one thousandth one millionth one billionth ten one hundred one thousand one million
Megapascal	(MPa)		Giga (G)	10 <sup>9</sup>	one billion
Newton kilonewton	(N) (kN)				
Joule	(J)				
degree celsius	(°C)				
gram kilogram Megagram	(g) (kg) (Mg)	(Metric Ton)			
kilogram per squar	e meter	(kg/m <sup>2</sup> )			

#### Metric Measurements

Hectare (ha)

Lengths = millimeters, meters, kilometers

Areas = square meters or hectare (10,000 square meters)

Volume = Liters or cubic meters

Mass = kilograms, metric tons

Force = newton ( $\dot{N} = kg \text{ m/s}^2$ )

Pressure, Stress = Pascal (Pa = N/m<sup>2</sup>)

Energy, Work = Joule (J = Nm)

Torque = Newton meter (N· m)

Speed, Velocity = meter/second, kilometers/hour

Acceleration = meters/second squared, kilometers/hours squared

Density = kilogram/meter cubed

Temperature = Celsius

Power = grams/Watt

Conversions	From English	To Metric	Multiply Quantity Units By
LENGTHS	inch	mm	25.4
	ft.	mm	304.8
	ft.	m	0.3048
	yd.	m	0.9144
	mile	km	1.609344
	mile	m	1609.344
	inches/mile	mm/km	15.7828
AREAS	sq. inch	mm <sup>2</sup>	645.16
	sq. ft.	m <sup>2</sup>	0.092903
	sq. yd.	m <sup>2</sup>	0.836127
	acre	m <sup>2</sup>	4046.856
	acre	ha	0.404685
	sq. mile	km <sup>2</sup>	2.59
VOLUME	cubic inch	mm <sup>3</sup>	16387.06
	cubic foot	m <sup>3</sup>	0.028316
	cubic yard	m <sup>3</sup>	0.764555
	gallon	L	3.78541
	gal./yd.	L/m	4.1398
	gal./sq. yd.	L/m <sup>2</sup>	4.5273
	gal./cubic yd.	L/m <sup>3</sup>	4.9511
	gal./acre	L/ha	9.354
	gal./ton	L/metric ton	4.1726
MASSES	ounces	g	28.349523
	pound	kg	0.453592
	kip(1000 lbs.)	metric ton	0.453592
	ton	metric ton	0.9072
FORCES	pound	N	4.44822
	kip	kN	4.44822
FORCE/UNIT LENGTH	l lb./ft. lb./inch	N/m N/mm	14.5939 0.1751
PRESSURE, STRESS	lbs./sq. ft.	Pa	47.8803
	kips/sq. ft.	kPa	47.8803
	lbs./sq. inch	kPa	6.89476
	lbs./sq. inch	MPa	0.006895
	kips/sq. inch	MPa	6.89476
ENERGY	foot pound	J	1.35582
MASSES/AREA	ounces/sq. yd.	kg/m <sup>2</sup>	0.0339057
	lbs./sq. ft.	kg/m <sup>2</sup>	4.8824
	lbs./sq. yd.	kg/m <sup>2</sup>	0.5425
	lbs./cubic ft.	kg/m <sup>3</sup>	16.01894
	lbs./cubic yd.	kg/m <sup>3</sup>	0.5933
	lbs./acre	kg/ha	1.1208
	ton/acre	metric ton/ha	2.2417
TEMPERATURE	(F - 32)/1.8 = C		

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